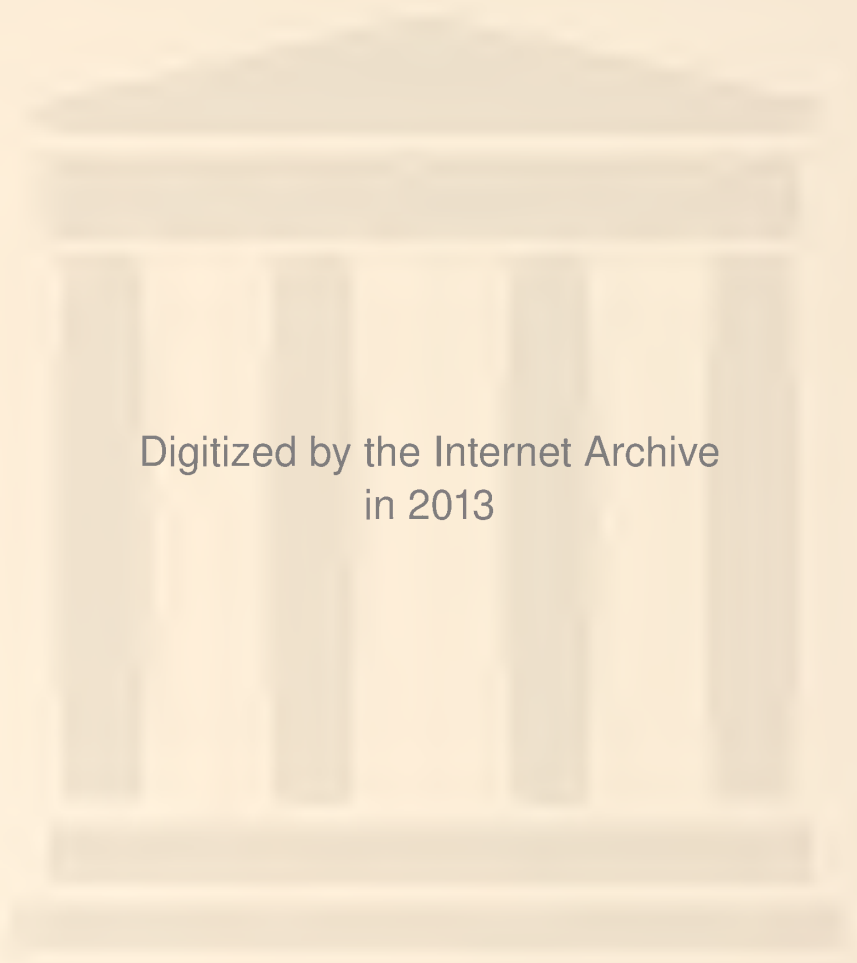


Cornell University Announcements

Graduate School of Medical Sciences 1986 • 1987





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Academic Calendar 1986-87

1986

Labor Day Holiday
Registration for Quarter I* and Fall semester**; orientation for new students

Quarter I and Fall semester begin
Quarter I ends
Examinations for Quarter I

Registration for Quarter II*

Quarter II begins
Thanksgiving recess

Winter recess: Instruction suspended 5:00 p.m.

Monday, September 1

Tuesday and Wednesday,
September 2 and 3
Thursday, September 4
Tuesday, November 4
Wednesday, November 5–
Friday, November 7
Friday, November 7 and
Monday, November 10
Monday, November 10
Thursday and Friday,
November 27 and 28

Friday, December 19

1987

Winter recess: Instruction resumed 9:00 a.m.
Last day for completing requirements for January degrees
Conferral of January degrees
Quarter II and Fall semester end
Examinations for Quarter II

Registration for Quarter III* and Spring semester***

Quarter III and Spring semester begin
Washington's Birthday observed
Quarter III ends
Examinations for Quarter III

Spring recess

Registration for Quarter IV

Quarter IV begins

Monday, January 5

Friday, January 16
Wednesday, January 21
Monday, January 26
Tuesday, January 27–
Friday, January 30

Friday, January 30 and
Monday, February 2
Monday, February 2
Monday, February 16
Friday, April 3
Monday, April 16–
Thursday, April 9
Monday, April 13, and
Tuesday, April 14
Tuesday, April 14 and
Wednesday, April 15
Wednesday, April 15

Seventh Annual Vincent duVigneaud Memorial Research Symposium; no classes	Tuesday, May 5
Last day for completing requirements for May degrees	Friday, May 22
Memorial Day Holiday observed	Monday, May 25
Commencement Day, conferral of May degrees	Thursday, May 28
Quarter IV and Spring semester end	Monday, June 15
Examinations for Quarter IV	Tuesday, June 16– Friday, June 20

Summer Term 1987

Registration for summer research	Monday, June 29
Summer research term begins	Monday, June 29
Last day for completing requirements for August degrees	Friday, August 21
Summer research term ends	Friday, August 21
Conferral of August degrees	Monday, August 24

*for students enrolling in courses

**for students conducting research only, who are on leave of absence, or are in absentia.

***for students changing from course work to research, who are going on leave of absence, or who are converting to in absentia status.

Note: Courses are taught on a quarterly basis; degrees are granted at ends of the Fall and Spring semesters and of the summer term. The dates shown in the calendar are subject to change at any time by official action of Cornell University.

In enacting this calendar, the Graduate School of Medical Sciences has scheduled classes on religious holidays. It is the intent of the school that students missing classes due to the observance of religious holidays be given ample opportunity to make up work.

Cornell Medical Center



Cornell University

Graduate School of Medical Sciences

Purpose

The Graduate School of Medical Sciences, a semi-autonomous component of the Graduate School of Cornell University, provides opportunities for advanced study and research training in specific areas of the biomedical sciences. Graduate programs leading to the degrees of Doctor of Philosophy are offered in biochemistry, biophysics, cell and developmental biology, developmental therapy, genetics, immunology, molecular biology, microbiology, neurobiology and behavior, pathology, pharmacology, physiology, and virology. Certain of these fields of study also offer programs leading to the degree of Master of Science. Collaborative programs with Cornell University Medical College lead to the combined degrees of Doctor of Philosophy and Doctor of Medicine.

The faculty of the Graduate School of Medical Sciences recommends the award of advanced general degrees not only as the result of the fulfillment of certain formal academic requirements, but also as evidence of the development and possession of a critical and creative ability in science. Demonstration of this ability is embodied in a dissertation which the candidate presents to the faculty as an original research contribution in the chosen area of study.

A close working relationship between student and faculty is essential to the program of the Cornell University Graduate School of Medical Sciences. Guidance for each student is provided by a Special Committee, a group of at least three faculty members selected by the student. This Special Committee is granted extraordinary independence in working with its student. Other than a broad framework of Graduate School of Medical Sciences requirements for residence, examinations, and a thesis, and additional requirements of the particular field of study chosen by the student, the Special Committee is free to design an individualized program of study with its students. No overall course, credit-hour, or grade requirements are set by the Graduate School of Medical Sciences. A student is recommended for a degree whenever the Special Committee judges the student qualified.

History

The opportunity for graduate study leading to advanced general degrees in the biomedical sciences was first offered at the Cornell University Medical College, in cooperation with the Graduate School of Cornell University, in 1912. In June of 1950, Cornell University, in association with the Sloan-Kettering Institute for Cancer Research, established additional opportunities for graduate study by forming the Sloan-Kettering Division of the Medical College. The resulting expansion of both graduate faculty and research training opportunities on the New York City campus prompted the organization in January 1952 of the Graduate School of

Medical Sciences, composed of two cooperative but separate divisions, known as the Medical College Division and the Sloan-Kettering Division. The Graduate School of Medical Sciences was given full responsibility for advanced general degrees granted for study in residence on the New York City campus of Cornell University.

Facilities

Despite the divisional structure of the Graduate School of Medical Sciences, the courses offered by the two Divisions are open to all students, as are the general facilities of the Divisions such as libraries, dining facilities, and recreational resources.

The Medical College Division. The buildings along York Avenue between 68th and 70th Streets accommodate both Cornell University Medical College and the Medical College Division of the Graduate School of Medical Sciences. Facilities available to graduate students include the Samuel J. Wood Library with a collection of over 136,000 volumes and subscriptions to 2,100 current journals, lecture rooms, teaching laboratories, seminar rooms and libraries of the basic science departments. Extensive research facilities are provided for faculty and students.

The Sloan-Kettering Division. Its facilities are located within the Sloan-Kettering Institute for Cancer Research, which consists of the Howard, Kettering, and Schwartz Laboratory buildings on East 68th Street. In addition, the Walker Laboratory is located in Rye, New York. Each provides lecture and seminar rooms, and together represent more than 100 laboratories, which are available for biomedical research training. The Medical Library, Nathan Cummings Center with 25,300 volumes of books and journals is located near the 68th Street complex.

Organization

The faculty of the Graduate School of Medical Sciences is composed of the faculties of the Medical College Division, consisting primarily of the professional staff of the basic sciences departments of Cornell University Medical College, and of the Sloan-Kettering Division, consisting of those professional staff members of the Sloan-Kettering Institute for Cancer Research who hold faculty appointments.

Within each of the Divisions are Fields (Medical College Division) and Units (Sloan Kettering Division) of graduate instruction which are formed by the faculty members in the respective Divisions with similar research and teaching interests. These Fields and Units of the Graduate School of Medical Sciences, as well as the Interdivisional Programs, represent areas of concentration in which advanced degrees are offered.

Executive Committee

The Executive Committee is both the administrative and judicial board of the Graduate School of Medical Sciences and its members have continuing responsibility for

the academic affairs of the school. The Committee is composed of the Chairpersons of the basic science departments of the Medical College Division and of the Programs of the Sloan-Kettering Division, the Directors of the interdisciplinary and interdivisional programs, the Dean and Associate Deans, the Provost for Medical Affairs of Cornell University, the Director and Associate Director of the Sloan-Kettering Division, the Chairperson and Vice-Chairperson of the Faculty Advisory Committee (see below), and two non-voting, elected student representatives.

The Executive Committee considers such matters involving the interests and policies of the Graduate School of Medical Sciences as are referred to it by the Faculty Advisory Committee, by individual members of the Faculty, or are generated upon its own initiative. The Committee approves the addition or deletion of fields of study, reviews the admission of students, approves a student's major and minor fields, reviews the curriculum and requirements for degrees.

The Executive Committee is chaired by the Dean, who is the academic administrative officer of the Graduate School of Medical Sciences and is also an Associate Dean of the Graduate School of Cornell University. An Associate Dean, who is also an Assistant Dean of the Graduate School of Cornell University, is the Secretary of the Executive Committee.

Faculty Advisory Committee

The Faculty Advisory Committee is the primary body representing the views of the Faculty of the Graduate School of Medical Sciences. The Committee advises the Dean and the Executive Committee on the impact of educational and policy matters under their consideration and recommends changes in educational activities, procedures, and policy of the Graduate School of Medical Sciences.

The Faculty Advisory Committee is composed of one elected faculty representative of each Field of the Medical College Division and of each Unit of the Sloan-Kettering Division, and one elected student representative from each Division. The Chairperson and Vice-Chairperson of the Committee are elected by its membership. Non-voting members are the Dean and Associate Deans, the Provost for Medical Affairs of Cornell University, and the Director and Associate Director of the Sloan-Kettering Division.

Special Programs

Medical Scientist Training Programs (M.D.-Ph.D.)

These programs are designed to expose a student to both medical and graduate disciplines during a six-year course of study. The combination of skills in basic research and experience in a clinical setting will prepare graduates from this program to pursue investigative careers in the biomedical sciences or in clinical medicine. The student spends the first two years as a medical student studying the basic medical sciences and attending regular graduate seminars. The summer months are spent in the laboratory learning experimental techniques and doing research. The third, fourth, and fifth years of the student's program are spent as a

full-time graduate student and are devoted mainly to laboratory research and writing the thesis. The sixth year of the program is devoted to clinical clerkships. This six-year program represents the minimum time required to satisfy residence requirements of both the M.D. and Ph.D. degrees at Cornell University. Successful applicants to the program will become M.D.-Ph.D. Fellows and will receive a full tuition scholarship and a stipend covering living expenses for the six-year period.

Separate Medical Scientist Training Programs are offered by the Medical College and Sloan-Kettering Divisions:

M.D.-Ph.D. Program at the Medical College Division: Preclinical and clinical training are provided by the faculty of Cornell University Medical College, while graduate education in research is offered by the faculty of the Medical College Division of the Cornell University Graduate School of Medical Sciences.

M.D.-Ph.D. Program at the Sloan-Kettering Division: This program is sponsored collectively by the Sloan-Kettering Division and Cornell University Medical College. The program requirements include the research-based Sloan-Kettering Division Ph.D. curriculum and the Cornell University Medical College curriculum.

For application to these programs, see p. 73.

Ph.D.-M.D. Program

Students enrolled in the Graduate School of Medical Sciences may be eligible for admission into the Ph.D.-M.D. Program, jointly sponsored by the Medical College and the Graduate School of Medical Sciences. This program is designed for those graduate students who find that their teaching and research goals require the acquisition of the M.D. degree in addition to the Ph.D. degree. The program is *not* designed as an alternate path for students who have the M.D. degree as their primary goal, but who have not been accepted by a medical school. Those who know, at the time of application to Cornell, that they want to pursue a course of study leading to both degrees should apply to one of the M.D.-Ph.D. programs described above.

See p. 73 for application and graduation requirements of the Ph.D.-M.D. program.

Faculty and Research Activities



Medical College Division

Field of Biochemistry

Faculty

John P. Blass
Adele L. Boskey
Esther M. Breslow
Arthur J.L. Cooper
Gordon F. Fairclough
Jerald D. Gass
Jack Goldstein
Owen W. Griffith
David P. Hajjar
Rudy H. Haschemeyer
Bernard L. Horecker
Chun-Yen Lai
Raymond E. Lockard
Alton Meister

Ursula Muller-Eberhard
Abraham Novogrodsky
Aaron S. Posner
Julian R. Rachele (Emeritus)
Albert L. Rubin
Edward T. Schubert
Richard L. Soffer
Kurt H. Stenzel
Suresh S. Tate
Sidney Udenfriend
Daniel Wellner
Kenneth R. Woods
David Zakim

Research Activities

Members of the field of Biochemistry are engaged in research spanning a wide spectrum of scientific areas. Thus, the research in *Dr. Meister's* laboratory is concerned with the study of enzymes, especially those involved in amino acid, peptide, and protein metabolism. It involves the isolation of enzymes, the determination of their structure and properties, and the use of techniques such as isolation of mRNA and cDNA. The research is basic in nature, but significant relationships between this research and human disease have been discovered and are also being explored. Current work involves the metabolism and function of glutathione, including the relationships of this tripeptide to transport, metabolism, radiation, and chemotherapy.

Dr. Boskey's research is concerned with elucidating the factors controlling physiologic and dystrophic calcification. Hydroxyapatite formation and growth are studied in solution, in collagen gels, and in animal tissues. Recent studies have concentrated on the mechanism of action of proteoglycans (a mineralization inhibitor) and acidic phospholipids (promoters of mineralization). Studies are also in progress on the role of vitamin D metabolites in bone lipid metabolism.

Dr. Breslow is concerned with understanding, in a quantitative sense, the forces that determine the specificity of protein-protein interactions. She has been studying the interactions of the pituitary peptide hormones, oxytocin and vasopressin, with their storage protein, neurophysin. These studies are directed towards elucidating the binding site regions of the hormones and of the protein

and at quantitating the energies of different components of the interaction. A second research project concerns the mechanism by which proteins are degraded intracellularly during normal protein turnover. The aims of these studies are to understand the precise role of ubiquitin, a small protein known to be involved in this process, and to elucidate the mechanisms underlying the selection of proteins for degradation.

Dr. Cooper's laboratory is working in the area of α -keto acid biochemistry and pyridoxal phosphate enzymes. Another area of active research is the metabolism of amino acids and ammonia in the brain. For this purpose, molecules labeled with short-lived radioisotopes are synthesized and their distribution in brain is analyzed by positron emission tomography. Cerebral energy metabolism, with particular emphasis on the malate-aspartate shuttle, and its disruption in various disease states are also being investigated.

Dr. Goldstein is studying the structure and function of erythrocyte surface antigens and is working on enzymatic methods for the removal of immunodominant sugars responsible for blood group A and B activity.

Dr. Griffith's research involves the design, synthesis and utilization *in vivo* of enzyme-selective inhibitors and substrates. These compounds are used both to evaluate and to control the metabolite flux through various pathways in intact animals. Recent studies have focused on the manipulation of glutathione and cysteine metabolism. Enzyme-selective inhibitors were developed that allow both glutathione biosynthesis and utilization to be blocked; techniques allowing extracellular cystine formation to be controlled were also developed. The inhibitors were shown to be useful in treating animal trypanosomiasis, enhancing oxidative killing of tumor cells, and preventing the formation of leukotriene C. New inhibitors are now being developed to allow *in vivo* control of carnitine metabolism. Applications of these compounds include the investigation and therapy of inherited diseases of lipid metabolism and diabetes.

Studies are currently in progress in *Dr. Hajjar's* laboratory to investigate the interaction of endothelial cells which line blood vessels with the underlying smooth muscle cells in an attempt to define the role of the endothelium in the process of cholesterol accumulation during arteriosclerosis. In addition, the role of herpes viruses as an etiological agent in the pathogenesis of lipid accumulation and arteriosclerosis is under investigation by studying the virus' effects on intracellular cholesterol metabolism and lipoprotein binding and metabolism.

Research in *Dr. Haschemeyer's* laboratory concentrates on the development of physical methods to study molecular structure and interactions, and on the application of such methods to ascertain structure-function relationships in selected systems. Current emphasis is directed toward computer modeling of biological flow methods and heterogeneous-phase reactions and on immuno-electron microscopy of human serum lipoproteins.

Dr. Horecker is working on the isolation and characterization of peptides from the thymus gland and evaluation of their possible function as hormones that regulate cellular immunity. The cloning of the genes for thymosin β_4 and for prothymosin α is a major current objective. Another project concerns the role of intracellular proteinases in the regulation of cellular processes, including their function in the turnover of intracellular proteins and in the cytotoxic effects of human lymphocytes.

Dr. Lai's research is concerned with the structure and function of cholera toxin. Work from his laboratory has shown that subunit A1 of cholera toxin is fully responsible for the toxin's ability to stimulate adenylate cyclase in mammalian cells. Isolated subunit A1 was also shown to catalyze an efficient transfer of the ADP-ribose moiety from NAD to a membrane protein. In another project, evidence has been obtained for a two-domain structure of the angiotensin converting enzyme: the hydrophobic carboxy-terminal portion of the enzyme is anchored to the cell membrane and the amino-terminal half, with the active site, is exposed to the blood circulation. Structural analyses indicate that the lung and testis enzymes may be the products of two distinct genes, and experiments are in progress to explain the close similarities between the two enzymes.

Dr. Lockard's research is directed towards understanding cytoplasmic control of eukaryotic gene expression. He is investigating the role of messenger RNA conformation in translational control and mRNA turnover. He is also studying the primary structure of rabbit 18S ribosomal RNA and its topography within the 40S subunit.

Dr. Muller-Eberhard is investigating the mechanisms of transport of iron protoporphyrin IX and its metabolic precursors by proteins in the blood stream as well as within hepatocytes. She is studying the exchange of porphyrins between proteins purified from serum and from hepatocytes; developing methods which delineate the function of these proteins in the delivery of porphyrins to hepatocytes and their intracellular distribution; and assessing the interaction of these proteins with artificial and biological membranes to learn how they may facilitate ligand transport across cellular and intracellular barriers.

Dr. Posner is studying bone mineral structure and properties with emphasis on the elucidation of the biochemical processes of tissue mineralization. Techniques such as x-ray diffraction, electron microscopy, and infrared absorption spectrophotometry are used in this project. The role in the mineralization process of the organic constituents of bone, such as collagen and proteoglycans, is of prime interest.

The main objective of *Dr. Soffer's* research is to characterize the physical, chemical, and biochemical properties of angiotensin II receptor which has been purified to a nearly homogeneous state from rabbit hepatic membranes.

Dr. Stenzel and *Dr. Novogrodsky* are interested in determining molecular mechanisms involved in lymphocyte activation. They are utilizing a model system of lymphocyte stimulation induced by the mitogenic oxidizing agents, sodium periodate and galactose oxidase. They are studying structural and functional alterations in cells rendered stimulatory by the oxidizing mitogens. These investigations include an analysis of the membrane sites oxidized and the possible cross-linked structures formed. Attempts are made to determine the requirements for stimulatory activity by reconstructions of stimulatory structures using hybridization and fusion techniques. They are also investigating structural and functional alterations in cells responding to aldehyde-modified stimulatory cells and cell fractions, and their requirements for soluble growth factors. Cell surface structures involved in accessory cell activity are being determined and biochemical events mediated by accessory cells or interleukin 1 are under study. A practical application of this work is a study to determine anti-tumor properties of lymphoid cells activated with the oxidizing mitogens.

Current interest in *Dr. Tate's* laboratory is focused on the isolation, characterization, and ultrastructural localization of enzymes responsible for the formation of modified N- and C-terminal residues of peptide hormones in the hypothalamus and the pituitary gland. Synthetic peptide substrates are being used to identify and isolate an enzyme from bovine pituitary glands which is responsible for the formation of the C-terminal amide group of several hormones. In another project, three brush-border enzymes are being used as model systems to gain an understanding of the processes involved in the assembly of the highly specialized microvillus membranes. The enzymes under study are γ -glutamyl transpeptidase, a dipeptidase, and aminopeptidase M. Current work includes a study of structure-function relations in these enzymes, their biogenesis, post-translational processing and sorting, and achievement of their final intracellular location.

Research in *Dr. Wellner's* laboratory is concerned with the structure and function of enzymes involved in amino acid metabolism, such as L-amino acid oxidase and threonine deaminase. Amino acid analyses of urine and blood of patients with inherited and acquired defects in amino acid metabolism are carried out as part of an effort to improve the diagnosis and treatment of these diseases.

Recent Publications

- Blass, J. P. (with Sheu, K.-F. R., and Lai, J. C. K.), Pyruvate dehydrogenase phosphate phosphatase in brain: Activity, properties, and subcellular localization. *J. Neurochem.* 40:1366-1372, 1983.
- Blass, J. P. (with Sheu, K.-F. R., and Lai, J. C. K.), Properties and regional distribution of pyruvate dehydrogenase kinase in rat brain. *J. Neurochem.* 42:230-236, 1984.
- Boskey, A. L. (with Chen, C.-C., and Rosenberg, L. C.), The inhibitory effect of cartilage proteoglycans on hydroxyapatite growth. *Calcif. Tissue Int.* 36:285-290, 1984.
- Boskey, A. L. (with Wians, F. H. Jr., and Hauschka, P. V.), The effect of osteocalcin on in vitro lipid-induced hydroxyapatite formation and seeded hydroxyapatite growth. *Calcif. Tissue Int.* 37:57-62, 1985.
- Breslow, E. (with Sardana, V.), Proton magnetic resonance and binding studies of proteolytically modified neurophysins. *J. Biol. Chem.* 259:3669-3679, 1984.
- Breslow, E. (with Whittaker, B., Allewell, N. M., and Carlson, J.), Enthalpies of ligand binding to bovine neurophysins. *Biochemistry* 24:2782-2789, 1985.
- Cooper, A. J. L. (with Fitzpatrick, S. M., Ginos, Z., Kaufman, C., and Dowd, P.), Inhibition of glutamate-aspartate transaminase by β -methylene-DL-aspartate. *Biochem. Pharmacol.* 32:679-689, 1983.
- Cooper, A. J. L. (with Mora, S. N., Cruz, N. F., and Gelbard, A. S.), Cerebral ammonia in hyperammonemic rats. *J. Neurochem.* 44:1716-1723, 1985.
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- Griffith, O. W. (with Jenkins, D. L.), DL-aminocarnitine and acetyl-DL-aminocarnitine. *J. Biol. Chem.* 260:14748-14755, 1985.
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- Haschemeyer, R. H. (with Todd, G. P.) Generalized finite element solution to one-dimensional flux problems. *Biophysical Chem.* 17:321-336, 1983.
- Haschemeyer, R. H. (with Wall, J., Hainfeld, J., and Mossesson, M. W.), Analysis of human fibrinogen by scanning transmission electron microscopy. *Annals N.Y. Acad. Sci.* 408:164-179, 1983.
- Horecker, B. L. (with Haritos, A. A., Blacher, R., Stein, S., and Caldarella, J.), Primary structure of rat thymus prothymosin α . *Proc. Natl. Acad. Sci. USA.* 82:343-346, 1985.
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- Muller-Eberhard, U. (with Cannon, J. B., Kuo, F.-S., Pasternack, R. F., and Wong, N. M.), Kinetics of the interaction of hemin liposomes with heme binding proteins. *Biochemistry* 23:3715-3721, 1984.
- Muller-Eberhard, U. (with Vincent, S. H.), Concepts of heme distribution within hepatocytes (Commentary). *Biochem Pharmacol* 34(6):719-725, 1985.
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- Posner, A. S. (with Thompson, D. D., Laughlin, W. S., and Blumenthal, N. C.), Comparison of bone appetite in osteoporotic and normal eskimos. *Calcif. Tis. Int.* 35:392-393, 1983.
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- Tate, S. S. (with Nash, B.), *In vitro* translation and processing of rat kidney γ -glutamyl transpeptidase. *J. Biol. Chem.* 259:678-685, 1984.
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Field of Cell Biology and Genetics

Faculty

Fred Allen
Rosemary Bachvarova
David M. Bader
Arthur Bank
J. Michael Bedford
Celso Bianco
Adele L. Boskey
Peter G. Bullough
Raju S. Chaganti
Moses V. Chao
Donald A. Fischman
James L. German III
Marvin Gershengorn
Lloyd H. Graf
Barbara H. Hosein
Patricia A. Jacobs
Eric Jaffe
Ralph L. Nachman
Joel D. Pardee

David M. Phillips
Enrique M. Rabellino
Joan Rankin Shapiro
James H. Ray
Michael Risley
Toby C. Rodman
Enrique Rodriguez-Boulan
Brij B. Saxena
Peter Sherline
Selma Silagi
Marcello Siniscalco
Julio L. Sirlin
Lisa Staiano-Coico
Paul Szabo
Martin Teintze
Paula Traktman
Doris A. Wall
Babette B. Weksler
David Zakim

Research Activities

Research is conducted in a broad range of fields which include the most exciting areas of genetics and cell, developmental and molecular biology. Excellent facilities and the most current methodologies are available.

The aim of *Dr. Bachvarova's* research is to understand the control of gene expression during meiotic maturation and early development of mammalian embryos. The role of maternal factors in the egg, and the differential expression and processing of mRNA's in the developing oocyte and embryo are being investigated. *Dr. Bader's* laboratory is concerned with the development of the heart. Specific interests are the differential expression of myosin heavy chains in the developing myocardium, and the mechanisms by which myocardial heterogeneity are generated. Monoclonal antibody and recombinant DNA technologies provide the basis for these studies of cardiac myogenesis *in vivo* and *in vitro*. Processes in both the male and female reproductive systems which contribute to conception are the focus of research in *Dr. Bedford's* laboratory. The cellular events undergone by spermatozoa during their maturation in the epididymis are under study; in the female, research is directed toward understanding sperm capacitation, sperm transport to the site of fertilization, and to the mechanism of fertilization.

The research in *Dr. Bullough's* laboratory concerns bone morphology, with a special interest in cartilage structure and joint geometry. *Dr. Chaganti's* laboratory is studying the role of hereditary factors in the etiology of human cancer. Molec-

ular, cytogenetic and epidemiologic approaches are being taken. Two main foci are the isolation and characterization of recessively inherited genes which appear to create a predisposition to chromosome breakage, and the study of the position and activation of cellular oncogenes. *Dr. Chao's* research interests focus on gene expression and regulation in mammalian cells. Cell surface molecules which regulate and change the pattern of transcription are under study. Molecular genetic techniques are being applied to such molecules as the human nerve growth factor receptor and specific human carcinoma and melanoma surface antigens.

Dr. Fischman's research focuses on the cell and molecular biology of sarcomere assembly in developing skeletal and cardiac muscle. Monoclonal antibody and recombinant DNA technologies, as well as electron microscopy and fluorescence energy transfer, are being applied to the study of post-translation steps involved in myofibrillogenesis. Several aspects of human genetics are under study in *Dr. German's* laboratory, including disturbances of malformation, disturbances of sexual development, and human cancer. Somatic cell genetic and cytogenetic approaches are being used. The focus of *Dr. Gershengorn's* laboratory is the understanding of hormonal regulation of cellular secretion. In particular, the stimulation of the anterior pituitary gland's secretion of thyroid-stimulating hormone and prolactin by thyrotropin-releasing hormone is under study. Research is now centered on the apparent importance of calcium in this system, and on phosphoinositides, which are implicated in cellular calcium homeostasis.

Dr. Jacob's laboratory is involved in cytogenetic and molecular analysis of human chromosome abnormalities, with emphasis on studying trisomies and the fragile X chromosome.

Dr. Jaffe's interest is in the response of endothelial cells to exogenous stimuli; current research includes study of the interaction of thrombin with endothelial cell surface proteins and the resultant induction of prostaglandin and thrombospondin production. Interactions of endothelial cells and white blood cells is also under study.

The focus of work in *Dr. Nachman's* laboratory is the biochemistry of platelet membranes and the macromolecular assembly of adhesive proteins on various cell surfaces and in the extracellular matrix. The structure and function of blood vessel walls is also under study. *Dr. Pardee's* research is concerned with the regulation of the actin cytoskeleton by actin-binding proteins. Two such regulatory proteins, severin and an actin filament bundling factor, have been isolated and are being analyzed for their roles in cell migration, cell-substrate adhesion and neoplastic transformation. The laboratory of *Dr. Risley* employs cell and organ culture techniques to elucidate the cellular and molecular parameters important for the regulation of spermatogenesis. Tissue culture and cytogenetic methods are being used to investigate the chemical induction of heritable chromosome aberrations.

Dr. Rodriguez-Boulant's main interest is an understanding of the cellular and molecular mechanisms that regulate the traffic and targeting of membrane proteins in eucaryotic cells, with an emphasis on the polarized distribution of apical and basolateral plasma membrane proteins in epithelial cells. Some specific topics are the determination of factors which aid in establishing polarity and the sorting signals which target specific proteins to their destinations. *Dr. Sberline's* research is directed towards understanding the role of microtubule associated proteins (MAP) in the regulation of microtubule assembly and function. With a particular interest

in the role of MAP's in the centrosome, immunological techniques are being used to study MAP distribution, metabolism and function during the cell cycle and in response to hormones and growth factors.

The main focus of *Dr. Traktman's* research is a molecular genetic analysis of vaccinia virus. Of particular interest are the temporal regulation of gene expression and the coordination of viral DNA replication. A variety of molecular, genetic and biochemical techniques are being employed to identify and characterize viral functions involved in DNA replication and the maintenance of DNA conformation. *Dr. Wall's* laboratory conducts research in membrane biology, with an emphasis on receptor-mediated endocytosis and an analysis of intracellular membrane systems. The *Xenopus* oocyte is being used as a model cell to study the pathways of ligands and receptors during endocytosis, and the establishment and maintenance of distinct membrane systems during oogenesis and early embryonic development.

Recent Publications

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Field of Microbiology, Immunology and Pathology

Faculty

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Carl G. Becker
Kenneth I. Berns*
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Robert W. Dickerman
Paul Edelson
John T. Ellis
Erik Falck-Pedersen*
David Hajjar
William Holloman*
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Jan S. Keithly
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Constance D. Rothermel
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Laurence B. Senterfit
Gregory W. Siskind
Kurt H. Stenzel
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Research Activities

The research activities in the Field of Microbiology, Immunology and Pathology cover a broad spectrum of interests including: the molecular biology and structure of microorganisms, host response to foreign antigens and the mechanisms and natural history of disease.

Emphasis is given to the molecular biology of microorganisms as it underlies their replication and the mechanisms of microbial pathogenesis. Microbes are of interest because their simplicity renders them attractive model systems to study the fundamental processes of life; on the other hand, they are of intrinsic interest as subjects to study both as a distinctive life form and because of their impact on other forms of life as parasites and/or symbionts. Because of the rapid development of molecular biological techniques, in particular genetic engineering, microbiologists are now in a uniquely favorable position to ask ever more meaningful and sophisticated questions about basic mechanisms and then to apply the answer to practical problems of infectious diseases. Currently, both basic and applied studies of viruses, bacteria, fungi, and parasites are ongoing within the Field.

Major programs are also directed to the study of cardiovascular disease and how basic pathophysiologic processes such as inflammation, blood coagulation and perturbation in the immune system and its regulation contribute to arteriosclerosis and its complications and the pathogenesis of Chagas' disease or South American trypanosomiasis. Together, these diseases are the major causes of cardiovascular deaths world-wide. Much of the research carried out involves extensive collaboration with investigators in other disciplines, especially immunology and hematology. We are convinced that this interdisciplinary approach is essential to understanding

disease mechanisms and also provides a unique opportunity for graduate students by increasing the intellectual diversity of the research program.

Many members of the program also have clinical responsibilities. We regard this as a major research resource because problems relating to the diagnosis, etiology, and mechanisms of progressive disease processes arise constantly. Presentation and discussion of these make up an important part of the educational conferences within the Field. They also provide a never ending source of subjects and ideas for both basic and applied research.

Dr. Alonso's research concerns the pathology of cardiovascular disease, including the pathogenesis of atherosclerosis, heart attacks and valvular heart disease.

Dr. Barany is concerned with two areas. The first has to do with protein engineering. He has developed a promising technique by which two additional amino acids can be inserted at any place along a protein using the modern techniques of molecular genetics and recombinant DNA technology. He is using this approach to characterize the specific biological activities of different domains of several proteins. Secondly, *Dr. Barany* is interested in developing DNA transformation as a genetic tool in the study of trypanosomes.

Dr. Carl G. Becker's research concerns the elucidation of the mechanisms by which tobacco constituents induce cardiovascular disease, including progression of arteriosclerosis and thrombosis through mechanisms that involve the immune system. These studies also include the mechanisms by which smoking is associated with the development of chronic pulmonary disease through activation of inflammatory pathways.

Research in *Dr. Berns'* laboratory concentrates on the elucidation of the mechanisms of replication of the defective human parvovirus, adeno-associated virus. These studies include DNA structure, the role of latent infection in the replication process, and gene regulation.

Dr. Dickerman's research relates to the ecology of arboviruses.

Dr. Edelson studies the relationship between intracellular parasites and phagocytic cells. He is interested in the physiology of macrophage activation and recently has studied the role of macrophage plasma membrane enzymes as differentiation markers during macrophage activation.

Dr. Ellis' research concerns the natural history of polycythemia vera and other myeloproliferative disorders of the hematopoietic system.

Dr. Falck-Pedersen investigates the mechanism of regulation of RNA transcription in eukaryotic cells. He is currently using the adenovirus genome as a model system in which to study *cis* acting sequences responsible for the termination of transcription. He has been able to demonstrate that specific sequences are associated with termination of RNA synthesis.

Dr. Hajjar's research concerns the biology of the cellular constituents of blood vessels and changes in these that lead to the development of atherosclerosis. He is particularly interested in the role of viral infection in the development of arteriosclerosis.

Research in *Dr. Holloman's* laboratory centers on the biochemistry and molecular biology of genetic recombination utilizing the fungus *Ustilago maydis* as a model system. *Dr. Holloman* has been able to develop an *in vitro* assay for homologous DNA recombination. The specific steps involved in the process of recombina-

nation and the specific substrates required for each step are currently being defined in his laboratory. The gene coding for the enzyme is being cloned and its regulation in mitotic and meiotic cells is being investigated.

Dr. Keithly's research is directed toward an understanding of the genetics of virulence in *Leishmania*. Currently she is in the process of isolating and characterizing the genes for ornithine decarboxylase and trypanothione reductase, two enzymes essential for growth, differentiation and survival of leishmania.

Dr. O'Leary's research is directed toward characterization of the lipid constituents in the membranes of bacteria and how these have been influenced by the advent of antibiotics. He is also interested in developing instrumentation for microbiological analysis.

The primary aim of *Dr. Murray's* work is the basis and expression of macrophage activation for enhanced antimicrobial activity. *Toxoplasma gondii*, *Leishmania donovani*, and *Mycobacterium avium-intracellulare* are used in in vitro and in vivo models as intracellular probes by which to examine the role of T cell-derived activating factors such as gamma interferon and interleukin-2. T cell-deficient AIDS patients are also being studied to determine the role and effect of immunoreplacement therapy with gamma interferon and interleukin 2 in man.

The focus of *Dr. M. O'Donnell's* laboratory is a detailed examination of the molecular mechanics of DNA replication. The dynamic motions on templates of the multi-protein replicative polymerase of *E. coli* and its interaction with other proteins at the replication fork are under study. Another project is the reconstruction of the replication of Herpes simplex virus Type 1 from purified proteins.

Dr. Petito investigates the response of constituents of the central nervous system to injury, particularly ischemic injury. This research is particularly relevant to the pathogenesis of and the recovery from the effects of stroke. Clinical research includes a study of neuropathological abnormalities in AIDS.

Dr. Prince's laboratory, at the New York Blood Center, is interested in the pathogenesis and prevention of viral hepatitis and other viral diseases transmitted through blood or blood products, particularly AIDS. In addition, studies on immunologic aspects of the parasite *Onchocerca volvulus* are underway.

In *Dr. Quimby's* laboratory, the pathogenesis of autoimmune diseases in dogs and laboratory animals is being investigated, with special emphasis on the role of functional subpopulation of T-lymphocytes as well as circulating immune complexes. Recently, a project aimed at elucidating the role of both active and passive immunity in toxic shock syndrome, was initiated, with emphasis on the pathogenetic role of toxin-antitoxin complexes using a baboon model.

Dr. Rothermel's laboratory is concerned with the nature of persistent infections with *Chlamydia*, the effect of interferon on chlamydial replication, the role of interferons and the mononuclear phagocyte system in controlling persistent infection, and the production of soluble immunoregulatory factors by the infected host.

Dr. Santos-Buch's research concerns the pathogenesis of Chagas' Disease, or South American trypanosomiasis. This research is aimed at elucidating the mechanisms by which trypanosomes infect host cells, and by which the immune response to these parasites can damage cardiac muscle.

Dr. Senterfit studies the antigenic structure and pathogenesis of mycoplasma with a special emphasis on the role of the attachment organelle. He is also carrying out research on the biology of respiratory syncytial virus.

Dr. Siskind is concerned with factors regulating the immune response. In particular, he is studying (1) the role of idiotype anti-idiotype interactions in determining clonal expression and (2) the role of T cells bearing receptors for the Fc of IgD in regulating the magnitude of the immune response.

Dr. Stenzel's areas of investigation include the study of a membrane associated interleukin 1 — like activity. He is examining the membrane molecules on human B lymphoblastoid cell lines that provide accessory activity for mitogen-treated, highly purified, T lymphocytes. A second project centers on the anti-tumor properties of lymphocytes activated by the oxidizing mitogens. Preclinical and clinical studies are underway to determine mechanisms of tumor cell destruction by activated lymphoid populations and their efficacy in reducing tumor burden in patients with metastatic renal cancer.

Research in *Dr. Traktman's* laboratory involves the molecular genetics of the replication of vaccinia virus DNA with a special emphasis on identification of the genes and the enzymes for which they code that are involved in this process. Currently, the vaccinia virus encoded topoisomerase has been isolated and its role in the replication process is currently being studied in detail.

Dr. Weksler's research concerns two areas: (1) The Biology of autoreactive T lymphocytes and (2) the immunobiology of aging. The former studies are aimed at understanding the development and regulation of the immune system; the latter at understanding the biological processes that lead to the diseases of aging.

Recent Publications

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Field of Neurobiology and Behavior

Faculty

Harriet D. Baker
Ira B. Black
Dana C. Brooks
Arthur J.L. Cooper
Cheryl Dreyfus
Daniel Gardner
Michael S. Gazzaniga
James G. Gibbs, Jr.
Gary E. Gibson
Bernice Grafstein
Katherine A. Halmi
Lorraine Iacovitti
Costantino Iadecola
Tong H. Joh
Joseph E. LeDoux
David E. Levy

J. John Mann
Hong M. Moon
Michiko Okamoto
Gavril W. Pasternak
Virginia M. Pickel
Fred Plum
Donald J. Reis
Walter F. Riker, Jr.
David A. Rottenberg
David A. Ruggiero
Leonard S. Schleifer
Jeri A. Sechzer
Gerard P. Smith
Peter E. Stokes
Gladys N. Teitelman
Robert Young

Research Activities

Dr. Harriet Baker is interested in quantitative immunocytochemical analysis of enzyme expression. The role of olfactory receptor neurons in control of neurotransmitter expression in the olfactory bulb with special reference to catecholamine and peptide neurons is a primary research focus. Strain and species differences in neurotransmitter expression is another research interest. The techniques used in these studies include immunocytochemistry, neurochemistry and neuronal tracing techniques.

Dr. Ira B. Black studies the molecular genetics underlying neuronal plasticity in the peripheral nervous system and the brain. A combination of *in vivo*, tissue culture, molecular biological, biochemical and morphologic techniques are employed to explore plasticity, and its role in the function of the nervous system. Developmental as well as aging models are being studied.

Dr. Dana C. Brooks is using signal averaging techniques to study the manner in which auditory information is processed as it passes through the first relay nucleus of the auditory system in the cat. The potential fields generated by the subdivisions of this nuclear complex are being mapped using an IBM XT and computer graphics programs.

Dr. Arthur J. L. Cooper is working in the area of 2-keto acid biochemistry and pyridoxal phosphate enzymes. Another area of active research is the metabolism of amino acids and ammonia in the brain. For this purpose, molecules labeled with short-lived radioisotopes are synthesized and their distribution in brain is analyzed by positron emission tomography. Cerebral energy metabolism, with particular emphasis on the malate-aspartate shuttle, and its disruption in various disease states is also being investigated.

Dr. Cheryl Dreyfus' research examines phenotypic development of specific neurons of the central nervous system and emphasizes definition of environmental factors which may influence brain cell development. This work has concentrated on ontogeny of noradrenergic neurons of the locus coeruleus, as well as dopaminergic cells of the substantia nigra and peptidergic and cholinergic neurons of the striatum and nucleus basalis.

Dr. Daniel Gardner studies how neurons use chemical synaptic transmission to communicate with one another. Neurons in ganglia of the mollusc *Aplysia* are probed by intracellular recording, voltage clamping, patch clamping, and computer-based analysis to yield principles of organization of cell networks. One project focuses on the particular kinetic properties of single transmitter-activated channels which are altered in order to determine duration, and therefore efficacy, of different postsynaptic currents. A second project asks how different synaptic currents function to coordinate the activity of neurons in a network.

Dr. Michael S. Gazzaniga utilizes neuropsychological approaches to behavior in man to examine the effects of corpus commissurotomy ("split-brain" surgery) on cognition with reference to interhemispheric interaction. These neuropsychological studies are carried out on patients who have had NMR (nuclear magnetic resonance) scans to determine the true extent of callosal separation.

Dr. James Gibbs' research focuses on the neurobiology of motivated behaviors, especially the neuroendocrine mechanisms controlling feeding behavior in animals and the pathophysiology of eating disorders in humans.

Dr. Gary E. Gibson examines the relation of calcium, oxidative metabolism and neurotransmitters to altered mental function and cell death. These interactions are examined in animal models of conditions that alter mental function in man (aging, hypoxia, and thiamin deficiency) as well as in tissues from Alzheimer patients. *In vivo* neurotransmitter metabolism is related to behavior and to changes *in vitro*. Human studies include enzyme measurements on autopsied brain as well as studies of lymphocytes, red blood cells and cultured skin fibroblasts.

Dr. Bernice Grafstein is concerned with problems of nerve regeneration and the response of nerve cells to injury. Techniques used include light and electron microscopy and radioactive isotope methods for analyzing the axonal transport of proteins and other cellular constituents.

Dr. Katherine Halmi's current research on anorexia nervosa and bulimia nervosa includes long term follow-up studies, investigation of appetite and satiety mechanisms in eating disorder patients, assessing taste preferences, neurendocrine investigations and psychological assessments.

Dr. Lorraine Iacovitti's current research activities are directed toward the study of the developing nervous system. She is currently examining the principles which govern phenotypic expression of particular neurotransmitters in neurons of the peripheral and central nervous system.

Dr. Constantino Iadecola's primary interest is the regulation of cerebral circulation, metabolism and blood-barrier permeability, role of neural pathways and reaction to injury.

Dr. Tong H. Job's main interest is to study the biochemistry and molecular genetics of neurotransmitter enzymes and receptors, and neurospecific protein. Multidisciplinary studies with molecular biologists, developmental biologists, and histochemists include the structural analyses of genes coding for neurotransmitter

enzymes, gene regulation at transcriptional level, quantitative analysis of mRNAs, and gene expression during development and aging.

Dr. Joseph LeDoux studies the neural pathways mediating emotional information processing. Classical conditioning techniques are used to endow sensory stimuli with emotional significance. Through the use of anatomical tracing, lesion, the electrophysiological recording techniques, the contribution of various brain areas and their fiber connections to the coding of stimulus meaning is analyzed.

Dr. David E. Levy is developing techniques for predicting which comatose patients will recover and which will not. These efforts include utilization of positron emission tomographic scanning to study unconscious patients. He collects detailed clinical information on patients with stroke so that methods for predicting recovery from stroke can be developed as they have been for coma. Development of an easily-utilized data entry and analysis system designed to accept serial clinical data on patients with a variety of neurological illnesses is an integral part of these efforts. In the coming year, clinical trials of promising therapeutic agents for acute stroke will probably be initiated as well.

Dr. John Mann's research focuses on aminergic receptor regulation and transmission abnormalities in the central nervous system and peripheral tissues. Human postmortem brain tissue, peripheral blood cells with beta adrenergic and serotonergic receptor complexes and related animal models are utilized to study the normal and diseased state. The laboratory has a particular interest in the neurochemical correlates of depressive and anxiety disorders, suicidal behavior and the action of antidepressants.

Dr. Hong Mo Moon is currently investigating the molecular biology of human chromosome 21 (q221 and q222).

Dr. Michiko Okamoto investigates pharmacologic and neuropharmacologic bases of the tolerance and physical dependence and withdrawal caused by general CNS depressants. Barbiturates, alcohol and benzodiazepines are the prototypes for the study. A quantitative methodology for the pharmacologic characterization of tolerance and physical dependence on these CNS depressants in animal models, underlying neuronal mechanisms for these events, sleep disorders produced by these drugs are the primary interest. The approach to research is multidisciplinary involving a wide range of laboratory techniques including modern chromatographic methods for determination of drugs and neurochemical transmitter substances and electrophysiologic techniques for monitoring central and peripheral neuronal responses.

Dr. Gavril W. Pasternak is studying the molecular pharmacology of centrally active analgesics. Work in the laboratory currently is focused upon the biochemical and pharmacological characterization of the various opiate receptor subtypes. One goal of the laboratory includes examining membrane-bound and affinity-purified receptors and their potential coupling with effector systems. Another is the correlation of the various subtypes with specific opiate actions in vivo. Finally, the anatomical localization of these sites within the central nervous system is studied with quantitative autoradiography. Many of these approaches have utilized a series of opiate affinity labels developed within the laboratory.

Dr. Virginia M. Pickel studies ultrastructural synaptic interactions between monoaminergic and peptidergic neurons in brain. Present research is directed toward a more complete understanding of the synaptic circuitry between neurons

containing specific transmitters in the basal ganglia and in brainstem nuclei associated with central cardiovascular regulation. Specific interactions between central monoaminergic and peptidergic neurons are being examined in the adult and developing rat brain using immunocytochemical markers and electron microscopy. The peptides of current interest include opioids, substance P, neurotensin, and angiotensin.

Dr. Fred Plum, Chairman of the Department of Neurology, focuses his research efforts on cerebral metabolism in disease states and their identification of cellular-subcellular mechanisms responsible for ischemic cell death.

Dr. Donald J. Reis's research interests are the central neural and neurochemical mechanisms governing control of the autonomic nervous system, cerebral blood flow and metabolism. His research also includes mechanisms governing the death of brain neurons in response to aging and injury.

Dr. Walter F. Riker's studies on the neuropharmacology of nerve endings center on the mechanisms of drug action on neurons, neuronal processes and synaptic systems in both the peripheral and central nervous system. Current work is concerned with the pharmacologic and functional characterization of motor nerve terminals, and with the testing of the hypothesis that neuromuscular blocking, anticholinergic, and anti-myasthenic drugs act presynaptically as well as postsynaptically, by slowing recovery from depolarization, especially in motor nerve endings in tonic nerve-muscle systems.

Dr. David A. Rottenberg investigates neurological imaging with positron emission tomography (PET) and transmission computerized tomography (CT). PET studies have focused on the use of ^{82}Rb to measure blood-to-brain and blood-to-tumor transport rate constants and tissue plasma water volumes. Elucidating the acute effects of whole-brain radiation therapy and corticosteroids on these transport systems is another goal. Other studies employing ^{18}F -fluorodeoxyglucose (FDG) are designed to evaluate the toxicity of combined cranial irradiation and intrathecal methotrexate in long-term survivors of childhood acute leukemia. He also maintains a laboratory devoted to quantitative autoradiography.

Dr. D. A. Ruggiero's interests include: anatomical and neurochemical pathways in brain which maintain normal resting levels of arterial blood pressure; neural substrates of the baroreceptor reflex; pathways underlying the cerebellar regulation of autonomic activities and cerebral blood flow; areas of autonomic representation in cerebral cortex and brainstem reticular formation; adrenaline synthesizing neurons and their pathways in the central nervous system.

Dr. Jeri A. Sechzer's research interests include early development, behavioral toxicology, sensory receptors, and neural mechanisms of memory and learning. Her current activities include: (1) The effect of lithium chloride on maternal behavior and early development; (2) Olfactory and gustatory thresholds in depression; (3) Bioethical issues concerning the use of animals in research and education.

Dr. Gerard P. Smith is interested in the behavior neuroscience of eating and its disorders. Current experiments include the measurement of central monoamines during eating behavior, the role of gut peptides such as cholecystokinin, to stop eating, animal models of eating disorders using genetic and sham feeding rats, and the experimental analysis of taste and eating in human patients with various types of eating disorders.

Dr. Peter E. Stokes is interested in neuroendocrine function in affective disease. Measurements of hypothalamic-pituitary-adrenocortical (HYPAC) function at various levels of this axis are obtained in patients with depression vs healthy normal controls and patients with other psychiatric diagnoses. Current specific interests include: response of the HYPAC system to administration of CRF, ACTH, dexamethasone and adrenocortical steroid blockers, pharmacokinetics of dexamethasone, measurement of multiple adrenal steroids, investigation of the relationship between HYPAC function and biogenic amine and sympathetic nervous system activity. A second area of interest is the investigation of lithium pharmacokinetics and the pharmacology-toxicology of lithium in animals and humans.

Dr. Gladys Teitelman's research interests include the cellular events controlling the expression of neurospecific proteins, such as neurotransmitter biosynthetic enzymes in autonomic ganglia of avian and mammalian embryos. Another area of her active research revolves around mechanisms involved in the differentiation of the endocrine cells of pancreatic islets from cells transiently expressing neurospecific enzymes. The techniques used in these studies include tissue culture, biochemistry and immunocytochemistry.

Dr. Robert Young's interest is in approaching relationships between brain neurotransmitter function and behaviors by studying major affective illness developing in late life. Indices of brain catecholaminergic function and behaviors are studied in individuals when symptomatic and after treatment. The laboratory measures applied include neurotransmitter metabolite excretion, neuroendocrine tests, brain imaging, and psychotropic drug concentrations.

Recent Publications

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Field of Pharmacology

Faculty

Walter W. Y. Chan
Diane F. Felsen
Owen W. Griffith
Charles E. Inturrisi
Roberto Levi

Michiko Okamoto
Gavril W. Pasternak
Marcus M. Reidenberg
Arlene B. Rifkind
Hazel H. Szeto

The members of the Field of Pharmacology, Cornell University Medical College Division, jointly offer the Interdivisional Program in Pharmacology with members of the Unit of Developmental Therapy and Clinical Investigation, Sloan-Kettering Division. Areas of training include: analgesic and opioid pharmacology; biochemical pharmacology and toxicology; cancer chemotherapy; cardiovascular pharmacology; clinical pharmacology; endocrine and peptide pharmacology; neuropharmacology; oncology-pharmacology; perinatal pharmacology and renal pharmacology.

Faculty, research activities, and publications relating to this joint training program are presented under Interdivisional Program in Pharmacology (p. 55). Program requirements and offerings are described also under Interdivisional Programs (p. 89).

Field of Physiology and Biophysics

Faculty

Olaf S. Andersen
Ellen Townes-Anderson
Rodney E. Bigler
Walter W. Y. Chan*
Colin Fell
Daniel Gardner
Marvin C. Gershengorn
Bernice Grafstein
Roger L. Greif (Emeritus)
Chin OK Lee
Roberto Levi*

Chiann-Tso Lin
Martin Lipkin
Thomas M. Maack
Daniel Nachshen
Lawrence Palmer
Thomas G. Pickering
Enrique M. Rabellino
Barbara Rayson
John L. Stephenson
Bernd W. Urban
Allan M. Weinstein
Erich E. Windhager

*Members of the Field of Pharmacology. For representative bibliography, see Interdivisional Program in Pharmacology.

Research Activities

Dr. Erich Windhager's studies are aimed at the elucidation of the mechanisms of ion and water transport by renal epithelial cells. The techniques used in Dr. Windhager's laboratory include: isolated perfused renal tubule segments, intracellular measurement of ions by ion selective electrodes, electrophysiological techniques, isolated membrane techniques and renal micropuncture methods. Current work centers on the role of cytosolic calcium ions as regulators of ion and water transport in proximal tubules and collecting ducts of the kidney. Collaborating with Dr. Windhager are Drs. Heinz, Frindt, Lin and Johnson.

Dr. Grafstein investigates nerve regeneration and transport of material in nerve axons. She is presently studying regeneration of goldfish optic nerve. Some of the conclusions reached in recent work are: drugs that disrupt microtubules produce metabolic effects in axons which resemble those produced by axotomy; increased synthesis of most transported proteins occurs during regeneration; removal of a synaptic target delays cell recovery during regeneration. Dr. Grafstein's laboratory uses the following techniques, among others: isotope tracer studies, electronmicroscopy, high resolution autoradiography, and 2-dimensional gel electrophoresis.

Dr. Maack's studies are directed at the elucidation of the quantitative aspects and mechanisms of renal processing and actions of circulating proteins and peptide-hormones. The main findings in this regard are that the uptake of proteins by proximal tubular cells is a high capacity-low affinity selective endocytic transport process. Disposal of absorbed protein is also a selective process which depends on an appropriate acid pH of lysosomes. The renal processing of low molecular weight proteins and peptide hormones accounts for a major fraction of the plasma turnover of these substances. The results of these studies permitted a better understanding of the pathophysiology of proteinurias and hormonal disturbances in renal diseases. More recent studies deal with the renal processing and actions of atrial natriuretic factor, a novel hormone secreted by the heart which decreases blood pressure, regulates kidney function and increases salt excretion. The techniques used in Dr. Maack's laboratory include isolated perfused rat kidney, isolated tubule segments, cell culture, receptor-hormone interactions and general biochemical and physiological techniques.

Dr. Andersen is interested in the mechanisms by which ions cross membranes. His studies entail analysis of permeability characteristics of lipid bilayers, with emphasis on the physical and chemical properties of proteins which serve as channel formers. The emphasis of the present work is on structure-function studies of membrane channels using site-specific amino acid substitutions, and on covalent modification of using group specific reagents. Techniques used in Dr. Andersen's laboratory include: single channel analysis, electrophysiological measurements, physio-chemical analysis, and computer simulations.

Dr. Stephenson is interested in theoretical aspects of transport in biological systems. Much of his recent research centers on transport of water and electrolytes in epithelia and in the kidney. One group of current studies focuses on the relation of medullary concentration gradients and the osmolality of final urine in the mammalian kidney to tubular and vascular permeabilities, flows, and architecture.

A second project is to develop a mathematical model of electrolyte transport in the whole kidney, which includes electrolytes (Na, K, Cl, HCO_3 , H_2PO_4 , H), glucose, urea, protein, osmotic forces, hydrostatic pressure, and electrical potential. Approaches to these problems include both computer simulation and the development and theoretical analysis of mathematical models.

Dr. Gershengorn studies the molecular mechanisms involved in signal transduction by hormones, neurotransmitters and growth factors that interact with receptors on the surface of their target cells. In particular, he is studying the biochemical events that mediate the stimulation by thyrotropin-releasing hormone (TRH) of secretion of hormones from the anterior pituitary gland. This mechanism involves the metabolism of an important class of cell phospholipids, the phosphoinositides, to generate two second messengers, inositol triphosphate and 1,2-diacylglycerol, and changes in cellular calcium homeostasis. This mechanism is a general one that is used by many extracellular signal molecules acting in many different cell types.

Dr. Pickering's main area of research is concerned with development of improved methods for the noninvasive measurement of blood pressure. First, he is using ambulatory monitoring techniques to learn more about the causes of blood pressure variability in normal and hypertensive subjects. This work has shown that most of the observed circadian rhythm of blood pressure can be accounted for by changes of activity. Second, he is analyzing the causes and origins of Korotkoff sounds with a view to the development of a new technique for blood pressure measurement.

Dr. Fell studies the reactivity to drugs and other stimuli of microvessels in rat and rabbit ears and rat mesentery, using the technique of ultravital microscopy.

Dr. Gardner's laboratory studies how neurons use chemical synaptic transmission to communicate with one another. He is concerned with the biophysics of synaptic transmission, as well as the properties of neuronal networks. Recent discoveries were: 1) choline activates inhibitory acetylcholine receptors of *Aplysia* buccal ganglia, and 2) dual-function excitatory-inhibitory synapses co-ordinate the two phases of their postsynaptic potentials by a voltage-dependent change in duration. Techniques used by Dr. Gardner include electrophysiological voltage- and patch-clamping, computer data acquisition and analysis, and artificial intelligence methods for neuronal modelling.

Dr. Lee investigates ionic mechanisms underlying changes in contractile force of cardiac muscle and ion transport across cardiac cell membrane. He recently demonstrated that cardiac glycosides increase cardiac muscle contractility by changing intracellular activities of sodium and calcium ions. Techniques used in Dr. Lee's laboratory include: isolated cardiac Purkinje fibers and intracellular recordings with ion selective electrodes (Na, H and Ca).

Dr. Palmer's research focuses on the mechanism of transepithelial Na reabsorption by tight epithelia, and the control of this process by hormones and other factors. The nature of the transport system facilitating sodium movement across the apical membrane of epithelial cells is being elucidated using the toad urinary bladder and the mammalian cortical collecting tubule as a model epithelia. Techniques used in Dr. Palmer's laboratory include: patch-clamping, current-voltage analysis, and flux ratio analysis.

Dr. Rabellino's research interests are primarily related to the study of the several cellular and molecular processes involved during the acquisition of functional competence by differentiating blood cells. In past studies he has investigated in the lymphoid, myeloid and megakaryocytic series, the phenotypic evolution of developing marrow cells using monoclonal antibody technology and flow cytometry. Currently, studies are in progress to investigate protein synthesis, cell DNA distribution and synthesis, as well as RNA accumulation in developing megakaryocytes. Studies are also in progress to assess expression and changes of specific protein genes throughout megakaryocytopoiesis using cDNA probes for different alpha granule proteins.

Dr. Nachshen's laboratory studies fundamental properties of presynaptic nerve terminals. Since calcium entry into the nerve terminal triggers the release of neurotransmitter substances, Dr. Nachshen is studying the detail of this process and how internal pH and intracellular calcium are related to neurosecretion. Techniques used in Dr. Nachshen's laboratory include: use of pinched-off nerve endings (synaptosomes), measurements of intracellular calcium with optical indicator substances.

Dr. Rayson's research activities center on the investigation of the regulation of Na-K/ATPase (Na pump) in kidney cells. Recent discoveries include the finding that intracellular Na levels regulate the number of active Na-K/ATPase enzyme sites in outer medullary tubular segments of the kidney. Current research is directed at the analysis of the cellular mechanisms involved. Techniques used in Dr. Rayson's laboratory include: superfusion of tubular segments of the kidney, protein purification, pulse-chase and in vitro translation experiments.

Dr. Urban studies the molecular actions of general anesthetics on membrane ion channels. He is investigating the mechanisms by which anesthetics change sodium and potassium currents in nerves (squid giant axon) and which effects anesthetics have on single sodium and gramicidin A channels (in lipid bilayer systems). Techniques used in Dr. Urban's laboratory include: voltage-clamp, electrophysiological techniques and lipid bilayers.

Dr. Weinstein is interested in the theory of solute and water transport across epithelia and developing a mathematical model of proximal tubular function using computer techniques.

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*Manhattan Skyline from
Cornell Medical Center.
Part of Memorial Sloan-Kettering
Cancer Center at lower right.*



Sloan-Kettering Division

Unit of Cell Biology and Genetics

Faculty

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Dorris J. Hutchison
Ione A. Kourides
Paul A. Marks
Myron R. Melamed
Malcolm A. S. Moore
Louis M. Pelus
Richard A. Rifkind
Marcello Siniscalco
Martin Sonenberg

Research Activities

The staff and faculty of the Cell Biology and Genetics Unit explores aspects of developmental cell biology, the growth and differentiation of normal and transformed cells; endocrinology and hormone receptors; genetics, cytogenetics and somatic cell genetics. These studies are pursued using the most modern cellular biologic, genetic, molecular biologic and immunologic methodologies.

Specific study is aimed at understanding cellular and molecular mechanisms that control coordinated gene expression and cell proliferation during induced cell differentiation, changes in DNA and chromatin structure that accompany cell differentiation, and regulatory interactions involved in the proliferation and differentiation of normal and neoplastic hematopoietic and lymphoid cells. Laboratories in this Unit are now identifying the specific genes and gene products responsible for the control and arrest of cell proliferation. This has led to the isolation, characterization and purification of growth factors (the interleukins, human granulocyte-macrophage colony-stimulating factor, melanocyte growth promoting activity) which may play crucial roles in regulating the growth and/or differentiation of cells.

The regulation of cell growth and function by extracellular agents such as peptide hormones, growth factors and neurotransmitters is under investigation. This involves characterization of plasma membrane structure and function; the relationship between peptide hormone receptor structure and transmembrane signaling; structure and regulation of glycoprotein hormone gene expression; structure of intracellular receptors for steroid hormones; and the properties, functions and hormonal regulation of intracellular peptidase activities.

Mechanisms leading to gene amplification and the expression of drug resistance in cultured cells are being examined. The role of homogeneously staining regions, double minute chromosomes and overproduced gene products in drug

resistant cells and as related to expression of the malignant neuronal phenotype by human neuroblastoma cells is therefore being investigated. The human genome is being mapped. Other research focuses on hereditary factors in the etiology of cancer and leukemia in humans as well as the identification of individuals with inherited susceptibility to cancer through understanding mechanisms leading to the initiation and progression of neoplasia. In the area of human tumor cell biology, the protein products of cellular oncogenes are being identified and characterized. The relationship between the expression of these unique gene products and cellular transformation is now under intensive investigation.

Of major interest to *Drs. Rifkind* and *Marks* are the cellular and molecular mechanisms that control coordinated gene expression and proliferation during induced cell differentiation. The principal experimental model is the murine erythroleukemia cell, which is a virus-transformed red blood cell precursor arrested in its normal developmental process at a stage of the erythropoietic lineage called the colony-forming cell for erythropoiesis. Studies of the mechanisms implicated in the control of gene expression have demonstrated that the globin gene domains in murine erythroleukemia cells have acquired a unique molecular configuration with respect to DNA structure and chromatin configuration. Current studies are designed to identify and characterize regulatory elements in the globin gene domains that may be implicated in the process of induced gene expression, and to identify genes regulating cell proliferation including protooncogenes and related sequences.

Dr. Biedler's research is directed toward understanding the genetic mechanisms underlying expression of acquired resistance to cancer chemotherapeutic agents. Of current interest is the development of multidrug resistance whereby cells selected with a single agent become cross-resistant to a wide variety of drugs. At least two amplified genes have been identified, one coding for a high molecular weight plasma membrane glycoprotein and the other for a low molecular weight cytosolic protein; the roles of the overproduced gene products are being explored. A second area of research is the cell biology of human neuroblastoma. This system, too, involves amplification of a specific gene and consequent cytogenetic abnormalities. Current studies are focused on the differential expression of the N-myc oncogene and the EGF receptor gene in morphological subtypes of the tumor cells as related to their state of malignant transformation.

The primary efforts in *Dr. Siniscalco's* laboratory are the mapping of the human genome and its application to molecular diagnostics and the investigation of chromosomal fragility with special reference to aging and malignancy.

The role played by hereditary factors in the etiology of leukemia and other cancers in humans using molecular, cellular and genetic - epidemiologic approaches forms the basis of research in the laboratory of *Dr. Chaganti*. An additional research interest in this laboratory is the study of inherited disorders that predispose to neoplastic disease, notably the recessively inherited disorders: Fanconi's anemia, ataxia-telangiectasia, and Bloom's syndrome. Current molecular studies emphasize cloning of translocation junctions in lymphoma and isolation of the genes determining the above disorders; while genetic epidemiologic approaches address the problem of cancer etiology at the population and pedigree levels.

Of related interest are investigations of the concept of immune cell participation in hematopoiesis in *Dr. Moore's* laboratory. The roles of prostaglandin E and T cells are currently under investigation by *Dr. Pelus* in normal hematopoietic and aplastic anemia, and in allogeneic marrow transplantation. In this context, new techniques for treating mismatched marrow before transplantation are being developed. Together with Dr. Moore, Dr. Pelus is investigating the biological role of "pluripoietin" in sustaining long-term proliferation of pluripotential stem cells and primary myeloid leukemic cells.

The identification and characterization of factors involved in growth stimulation or differentiation of skin melanocytes and keratinocytes *in vitro* and the effect of cells grown in tissue culture and growth factors on wound healing *in vivo* is the focus of *Dr. Eisinger's* work.

Basic research is also underway in *Dr. Melamed's* laboratory to determine quantitative differences in cellular constituents that distinguish different classes of cells and in the molecular structure of sub-cellular components that are affected by cell differentiation, transformation and progress through the cell cycle. *Dr. Darzynkiewicz* is developing new probes and methods for multiparameter cell analysis by flow cytometry and applying them in studies on chromatin structure, cell cycle and cell sensitivity to anti-tumor drugs. Basic physicochemical studies on the interactions between intercalating drugs and nucleic acids are also underway in his laboratory.

Several investigators in the Unit are conducting research on hormones. *Dr. Donner* is studying, on a molecular level, how peptide hormone-receptor interactions are regulated and translated into changes of cell growth, differentiation, or metabolism. The long-range objective of *Dr. Sonenberg* is the molecular description of membrane transduction of peptide hormonal messages after interaction with a specific membrane receptor or other membrane component. *Dr. Kourides* studies the structure and molecular regulation of glycoprotein hormone genes and the molecular basis for human chorionic gonadotropin gene expression in normal and neoplastic tissues.

Dr. Balis' research is concerned with the regulation and function of a series of enzymatic reactions known as the "adenosine cycle". Intimately connected to this study are the functions of enzymes involved in the methylation of various nucleic acids.

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Unit of Development Therapy and Clinical Investigation

Faculty

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*Participants in the Interdivisional Program in Pharmacology

Research Activities

Research in this Unit includes the innovative operation of the first isochronous cyclotron to be used in a medical research institution, resulting in the capacity to visualize tumors as well as specific organs and tissues.

Studies are also being carried out to determine whether or not various tumor promoters could affect the expression of previously identified cell surface antigens on normal human melanocytes or melanoma cells. Satisfactory procedures have been developed for autologous transplantation of frozen and stored hematopoietic stem cells. Also under investigation are improved methods for purging marrow of residual tumor cells and the phenotypic characterization of human leukemias and lymphomas.

Investigators have been working with flow cytometry to detect cell surface membrane light chain expression in minimal numbers of B-lymphocytes. This technique, which is called clonal excess and requires a mathematical calculation, allows the detection of less than 5 percent of malignant cells in cell suspension.

Other research objectives of this Unit are to characterize the effects of various substances on the proliferation, differentiation, and identification of biochemical substances produced by selected childhood tumors and skin tumor tissue fibroblasts.

The research activities and recent publications of Drs. Chou, Fox, Fried, Otter, Sirotnak, and Watanabe are listed under the Interdivisional Program in Pharmacology (p. 55) in which these faculty members are participating. Requirements and course offerings of this program are also described under Interdivisional Programs (p. 89)

Dr. Schwartz's studies are related to the development and evaluation of tumor-marker assays in blood and tissues for use in the management of the patient with cancer.

*Drs. Laughlin, Gelbard, and Zeitz study the *in vivo* metabolism in cancer patients and in animal tumor systems using metabolites and analogues labeled with short-lived, positron emitting radionuclides. These isotopes are produced on the Sloan-Kettering Institute isochronous cyclotron and are incorporated into compounds by rapid organic methods or by immobilized enzymatic procedures.*

Drs. Geller, Groshen, Thaler, and Wong have developed a computerized data base for the storage and retrieval of clinical research data pertinent to the collection, processing and distribution of clinical samples to the research laboratories.

Recent Publications

Gelbard, A. S. (with Kaseman, D. S., Cooper, A. J. L., Meister, A., and Reiman, R. E.), Synthesis of hydroxyl (N-13) amine and binding of $^{13}\text{NH}_2$ O11 to two transaminases. *J. Label. Compds. and Radiopharm.* 21:803-844, 1984.

Geller, N. L. Statistical strategies for animal conservation. *Ann. N.Y. Acad. Sci.* 406:20-31, 1983.

Groshen, S. (with Li, W. K., Lane, J. M., Rosen, G., Marcove, R. C., Capanos, B., and Huvos, A.), Pelvic Ewing's sarcoma. *Advances in treatment. J. Bone Joint Surg.* 65:738-747, 1983.

Laughlin, J. S. (with Reiman, R. E., Rosen, G., Gelbard, A. S., Benau, R. S., and Yeh, S. D. J.), Diagnostic demands in clinical and experimental oncology. Applications of substrates labeled with positron emitting radionuclides. In: Knapp, W. H. and W. H. and Vyska, K. (eds) *Current Topics in Tumor Cell Physiology and Positron-Emission Tomography*. Heidelberg: Springer-Verlag, pp. 73-85, 1985.

Schwartz, M. K. (with Nisselbaum, J. S. and Fleisher, M.), High plasma ACTH values may be obtained on normal individuals with kits from CIA. *J. Clin. Immunoassay.* 8:23-28, 1984.

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Sternberg, S. S. (with Morrow, R., Wong, B., Finkelstein, W. E., and Armstrong, D.), Aspergillosis of the cerebral ventricles in a heroin abuser: Case report and review of the literature. *Arth. Intern. Med.* 143:161-164, 1983.

Thaler, H. T. (with Straus, D. J., Filippa, D. A., Lieberman, P. H., Koziner, B., and Clarkson, B. S.), The non-Hodgkin's lymphomas. I. A retrospective clinical and pathologic analysis of 499 cases diagnosed between 1958 and 1969. *Cancer* 51:101-109, 1983.

Wong, G. Y., Rank-one round robin designs. *J. American Stat. Assn.* 79:136-144, 1984.

Zeitz, I. (with Laughlin, J. S., Ma, I., and Pipman, J.), "Non-isolated-sensor" solid tissue equivalent A-150 plastic absorbed dose measurements. *Radiation Res.* 94:578-584, 1984.

Unit of Immunology

Faculty

Anthony P. Albino
Edward A. Boyse
Yvon Cayre
Bo Dupont
Neal Flomenberg
Ulrich Hammerling
Michael K. Hoffman
Alan N. Houghton
Robert W. Knowles

Janet Lee
Kenneth O. Lloyd
Herbert F. Oettgen
Lloyd J. Old
Richard J. O'Reilly
Bijan Safai
Fung-Win Shen
Osias Stutman
Soo Young Yang

Research Activities

The main interests of the Unit are the study of the development, general properties, function and regulation of the cellular components of the immune response, as well as the secreted products of such cells. Research is conducted in three main areas: 1) immunogenetics, especially the cell surface determinants involved in the differentiation and function of normal and malignant lymphoid cells; 2) cellular immunology, especially the cellular interactions and secreted cell products required for effective immune responses; and 3) tumor immunology, particularly the analysis of the immunological properties of the transformed tumor and host, aimed at designing possible diagnostic and therapeutic strategies. Research in these three main areas is done using both experimental animal models as well as human cells. Since immunology is multidisciplinary in its approaches to a given problem, it not only has generated its *own methodology* (such as the production of monoclonal antibodies, the continuous *in vitro* growth and cloning of the relevant lymphoid cells, the *in vitro* technologies for measurements of immunological function, etc.) but also uses the methods of other disciplines, such as *biochemistry* and *molecular biology*. For example, the analysis of the biological significance of a given membrane surface antigen is not only studied by applying conventional genetics and immunological function assays, but biochemically for the isolation of the given membrane surface antigen, definition of its structure and characterization of the gene(s) coding for such a determinant. Thus, the general approach of the research program is to define immunological events at the biological, biochemical, and molecular levels.

The Unit offers the opportunity for obtaining a Ph.D. degree with emphasis on the various sub-disciplines of immunology such as immunogenetics, immunochemistry, molecular immunology, immunopathology, tumor immunology, transplantation immunology and clinical immunology.

In the field of tumor immunology, *Dr. Albino's* laboratory is examining the role of specific oncogenes in the pathogenesis of malignant melanoma. This includes a comprehensive study of the steps required for the transformation of human melanocytes and nevocytes. In addition, this laboratory also studies the

structure and function of melanoma cell-surface differentiation proteins and their gene sequences.

Dr. Boyse's laboratory focuses on the description and understanding of genetic programs that specify the unique molecular constitution (surface phenotype) of the outer membrane of cells according to their developmental lineage and stage of differentiation.

The two main research objectives of *Dr. Cayre's* laboratory are to study cell surface immunogenetics at the molecular level and to investigate the molecular basis of cell differentiation and commitment.

The central themes for *Dr. Dupont's* laboratory are the characterization of the genetic composition of the genes of the human major histocompatibility complex (MHC); the investigation of the molecular genetic basis for the expression of these extensive genetic polymorphisms of the MHC-encoded cell surface antigens as detected in the population; and the biological role of MHC gene products in immunoregulation and other biological functions. The laboratory is also involved in investigations in the area of transplantation immunology, particularly in relation to the understanding of mechanisms responsible for graft vs. host disease.

Investigations in *Dr. Flomenberg's* laboratory focus primarily on the activation and effector functions of human lymphocytes. A large portion of this work concerns the molecular interactions between the T cell and its target, focusing on the major histocompatibility complex gene products that initially activate or serve as targets for T cells, as well as the T cell surface molecules that are important for T cell function. Additional studies of autoreactive T cells, natural killer cells, and the molecular genetics of B cell differentiation are in progress.

For the mouse, the majority of genes encoding lymphocyte antigens are organized in distinct multigene families positioned on several chromosomes. Study of these gene clusters continues to be the major theme of *Dr. Hammerling's* efforts. The immunogenetics of murine and human lymphoid and hemopoietic cell surface antigens using monoclonal antibodies is another area of *Dr. Hammerling's* studies, with special emphasis on their role in T cell activation.

The main interest of *Dr. Hoffmann's* studies is the analysis of the direct and factor-mediated cellular interactions in the human and murine antibody responses *in vitro*.

Dr. Houghton's research program to investigate the pathogenesis and treatment of malignant melanoma arises from his interest in the biology of human solid tumors. *Dr. Houghton* views malignant melanoma as a paradigm for the pathogenesis of human cancer. His studies involve the phenotypic and genotypic expression of antigens related to differentiation and transformation of melanocytes.

Dr. Knowles' laboratory has developed monoclonal antibodies that provide an extensive panel of unique probes to examine cell surface molecules and their functional epitopes. These have been used in the biochemical and genetic characterization of the human histocompatibility antigens and the differentiation antigens of the human T cell, B cell and myeloid lineages. Molecular analysis of a genomic rearrangement responsible for an inherited defect in the expression of a histocompatibility gene is in progress.

The molecular genetics of the human major histocompatibility complex or HLA genes is the major area of study of *Dr. Lee's* laboratory. Her work currently concentrates in initial studies of characterization and mapping of the genes within

the HLA region on human chromosome 6. These experiments focus on the presence in the genome of as yet uncharacterized HLA Class II genes.

Investigations of the glycoproteins and glycolipids of human tumor cells and normal cells are the focus of research in *Dr. Lloyd's* laboratory. Particular emphasis has been on the biochemical identification and characterization of these components.

The main effort in *Dr. Oettgen's* laboratory is on the serological analysis of human cancer antigens, the human and cellular immune responses to human cancer, and the development and application of human cancer therapies using cancer antigens, immunogenic cancer vaccines and monoclonal antibodies.

Dr. Old's research is concerned with the development of two new approaches to cancer therapy: tumor necrosis factor and monoclonal antibodies directed against surface determinants on malignant cells. The latter is part of a general effort to analyze the cell surface of human and murine tumors, with the aim to characterize the important surface molecules, mostly with monoclonal antibodies and other serological procedures.

The principal objective of *Dr. O'Reilly's* Bone Marrow Transplantation Program is the development and improvement of transplantation approaches for the treatment of lethal disorders of the blood system through an integrated program of clinical and basic research in immunology, hematology, genetics, and transplantation biology.

Investigation into the biology of epidermal keratinocytes and Langerhans cells is the focus of *Dr. Safai's* research, with the objective of defining the antigenic components of the epidermal keratinocytes and their secretory capacity and characterizing lymphocyte-epidermal interactions.

Working mostly with normal lymphoid cells and their leukemic derivatives, *Dr. Shen's* laboratory is particularly concerned with the regulation and function of genetic systems that participate in normal and disordered differentiation.

The definition of the steps involved in the development, maintenance and function of T (thymus-dependent) cells through the use of murine models has been one of the main areas of *Dr. Stutman's* research. Another area of interest is the study of the immunological components of the tumor-host interaction. These studies include the definition of tumor-specific responses; examination of the role of such responses in affecting tumor development and behavior, and the production of specific and non-specific cytotoxic cells that can kill tumor cells.

Dr. Yang is involved in studies of T-lymphocyte activation, lymphokine production and regulation, T-lymphocyte macrophage interactions, and characterization of T-lymphocyte differentiation antigens and their functions, as well as the gene organization and regulation of gene expression in the Class I MHC genetic region in humans.

Recent Publications

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Albino, A. P. (with Graf, L. H., Kantor, R. R. S., McLean, W., Silagi, S., and Old, L. J.), DNA-mediated transfer of human melanoma cell surface glycoprotein, gp130: Identification of transfectants by erythrocyte rosetting. *Mol. and Cell. Biol.* 5:692-697, 1985.

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- Flomenberg, N. (with Rosenkrantz, K., and Dupont, B.), Generation and regulation of autocytoxicity in mixed lymphocyte cultures: Evidence for active suppression of autocytoxic cells. *Proc. Natl. Acad. Sci. USA* 82:4508-4512, 1985.
- Flomenberg, N. (with Knowles, R. W., Williams, D., Horibe, K., Rosenkrantz, K., and Dupont, B.), T lymphocyte clones detecting novel supertypic HLA-class II allospecificities. *Immunogenetics* 22:295-300, 1985.
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- Hammerling, U. (with Palfree, R. G. E.), Biochemical characterization of the murine activated lymphocyte alloantigen Ly-6E.1 controlled by the Ly-6 locus. *J. Immunol.* 136:594-600, 1986.
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- Houghton, A. N. (with Dracopoli, N., and Old, L. J.), Random loss of polymorphic restriction fragments in human melanoma: implications for tumor initiation and heterogeneity. *Proc. Natl. Acad. Sci. USA* 82:1470-1474, 1985.
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- Old, L. J. (Rettig, W. J., Real, F. X., Spengler, B. A., and Biedler, J. L.), Human melanoma proteoglycan: Cell surface expression in hybrids controlled by intrinsic and extrinsic signals. *Science* 231:1281-1283, 1986.
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- Yang, S. Y. (with Chang, A., Olivero, R., Relias, V., and Yunis, E. J.), IEF patterns of HLA-B13 antigens for Orientals and Caucasians. *Immunogenetics* 21:125-134, 1985.

Interdivisional Programs

Molecular Biology

Faculty

Francis Barany
Kenneth Berns
Peter Besmer
Moses V. Chao
Eric Falck-Pedersen
Nancy G. Famulari
Erwin Fleissner
Mark E. Furth
Sohan L. Gupta
William S. Hayward
William Holloman
Jerard Hurwitz

Robert M. Krug
Elizabeth H. Lacy
Kenneth J. Marians
Peter W. Melera
Norma Neff
Michael E. O'Donnell
Paul V. O'Donnell
Jeffery V. Ravetch
Ora M. Rosen
Ganes C. Sen
Michael B. Sheffery
Paula Traktman

Research Activities

Several of the Fields and Units of the Graduate School of Medical Sciences jointly offer an interdisciplinary program of graduate research training in the structure, function and regulation of genetic elements, including control of normal gene expression, gene replacement, oncogenes and oncogene expression, oncogenic viruses, chromosome structure, nucleic acid replication, recombination and repair, and growth factors and their receptors.

In the laboratories, the control of gene expression is studied in a variety of viral and cellular systems, in cell-free systems, in cell culture, and in the intact organism. Influenza virus and adenovirus serve as models for the control mechanisms involved in the synthesis, processing and translation of RNA, both in the cell and in cell-free systems. Various eukaryotic virus expression vectors are being constructed for these studies. Virus-infected cells are also being employed for molecular studies of interferon action. Cells responsive to specific inducing agents are used to elucidate the regulation of gene transcription by peptide hormones, by interferon, and by chromatin structure. The gene amplification or rearrangement events frequently observed in tumor cells reveal the profound effects of such DNA alterations on gene transcription. Mice carrying new genes introduced by injection of DNA into early embryos provide novel examples of tissue-specific control of gene expression.

Research of the mechanism of both prokaryotic and eukaryotic DNA replication employs cell-free replication systems. Model systems have been developed to study the replication of SV40, herpes-simplex, vaccinia and adenovirus as well as leading- and lagging-strand DNA synthesis on the bacterial chromosome. These

studies hope to elucidate control elements and specific protein-nucleic acid interactions involved in eukaryotic DNA replication. Related studies are being carried out on the enzymological mechanisms involved in the recombination of chromosomes.

Much of the research on the control of cellular metabolism and growth focuses on crucial regulatory proteins involved in the transmission of signals at the cell membrane, including various cell surface receptors, protein kinases, and the calcium binding protein calmodulin. In addition to biochemical and physiological studies, substantial effort is being made to isolate and determine the nucleotide sequences of the genes encoding these important proteins.

The mechanism of action of viral and cellular genes directly implicated in neoplasia is under active investigation. Studies have shown that retroviruses in birds, rodents, and cats transduce a number of oncogenes encoding proteins that vary greatly in their cellular oncogenicity, leading to the development of specific cancers, such as lymphomas, thymomas and erythroleukemia. Activated oncogenes have also been identified in the DNA of animal and human tumors with no known viral etiology. The study of the mechanism of activation of these cellular genes and of their gene products may provide insight into the molecular basis of human cancer.

Dr. Krug's research focuses on the unique interaction of influenza virus with its host cells as a model system for elucidating control mechanisms involved in the synthesis, processing, and translation of both viral and cellular messenger RNAs.

Dr. Falck-Pedersen concentrates on developing an understanding of transcription in eucaryotic cells. In particular, a combined biochemical and molecular genetical approach is being used to analyze the termination of transcription by RNA polymerase II.

Dr. Hurwitz is conducting studies of prokaryotic and eukaryotic replication of DNA and RNA processing. These studies focus on the enzymes and enzymological mechanisms involved in these processes.

Dr. Traktman's laboratory also studies viral DNA replication in eukaryotes. Both biochemistry and molecular genetics are employed to define the genes of vaccinia virus that are required for its replication. An *in vitro* replication system is also being developed.

A laboratory with related research interests, headed by *Dr. Marians*, focuses on studies of the enzymological mechanisms of DNA replication in prokaryotes. The use of *in vitro* DNA replication systems composed of purified replication proteins enables detailed analyses of the interaction of the replication proteins with each other and with the DNA template.

A detailed examination of the molecular mechanics of DNA replication is also the focus of *Dr. M. O'Donnell's* laboratory. The dynamic motions on templates of the multi-protein replicative polymerase of *E. coli* and its interaction with other proteins at the replication fork are under study.

Another key cellular process that occurs on DNA is the exchange of genetic information through the process of recombination. *Dr. Holloman's* laboratory studies the enzymological mechanisms involved in this complicated process. Model studies focus on the mechanism of synopsis and DNA strand exchange promoted by the rec 1 protein.

The only families of linear DNA viruses that replicate in mammalian cell nuclei are the adeno-associated virus, the adenovirus and herpesvirus; the structure and function of one of these is the object of study of *Dr. Berns'* laboratory. This virus was selected because it is thought to be highly amenable to detailed longitudinal investigation, since it readily establishes latent infections in continuous cell lines in culture derived from the normal host. A study of this virus may also have bearing on the molecular biology of cellular DNA replication and transcription.

Research on the mechanisms of DNA uptake and homologous integration in naturally transformable bacteria is the basis for studies of the mechanisms of genetic transfer by *Dr. Barany*. Future research in this laboratory will shift to transformation mechanisms in eukaryotic cells with a view to the eventual development of gene therapy.

Elucidation of the mechanism of action of insulin and related growth factors, leading to a detailed understanding of the receptor molecule as well as the mechanism(s) by which it transmits signals from the cell surface to its interior is the principal goal of *Dr. Rosen's* research.

The gene for human nerve growth factor has been isolated by *Dr. Chao's* laboratory. Recombinant DNA technology is being used to study the important structural features of the gene and the molecular basis of differential receptor expression during development.

In a series of experiments in *Dr. Ravetch's* laboratory, the molecular genetic analysis of cell surface receptor proteins is being conducted, aimed at defining their modulation, mechanism of signal transduction and developmental regulation by isolation and characterization of genes that code for proteins binding immunoglobulin (FC receptors), by studying the interaction of the malaria producing parasite with the erythrocyte, and by characterizing the activated macrophage phenotype.

Several laboratories are intensely studying the development of leukemia in mice and humans. *Dr. Fleissner's* laboratory focuses on the genetic systems implicated in this process. Lines of research include several investigations aimed at determining the number and nature of the genetic steps involved in the derivation of malignant T-cells. Other studies involve collaborations with *Drs. P. O'Donnell, Hammerling, and Hoffman*, focusing on the *N-ras* oncogene's effects on T-cells. A third group of studies deals with the correlations between specific structural features of murine leukemia virus *env* gene proteins and their functions.

Dr. Famulari's research centers on studies of retrovirus-induced leukemogenesis in the mouse using intrathymic injection of virus in order to develop thymomas, a model well suited for analysis of progression of target cells from normal to malignant phenotype.

Dr. Hayward's research objective is to elucidate the mechanisms by which viral and non-viral agents induce neoplastic disease through the use of three classes of avian retroviruses as model systems.

Mutations affecting the structure and the control of expression of oncogenes contribute to carcinogenesis. *Dr. Furtb's* laboratory is engaged in research on the structure and function of the *ras* oncogene proteins. Genetically distinct *ras* generally are very similar, but differ dramatically in a small hypervariable region located near the carboxyl terminus. A major goal of the laboratory is to determine how this region contributes to the function of these proteins. A second area of study in the

laboratory concerns growth factors that regulate the proliferation and differentiation of hematopoietic cells.

Current research objectives of *Dr. Besmer's* laboratory are to investigate the structure and function of the proto-oncogene *KIT* to investigate its role in neoplastic transformation; and to determine the basis of the differing neoplastic potential of the murine and feline *abl* viruses.

The creation of systems in the mouse for the study of the development of T-cell leukemia is the major focus of *Dr. P. O'Donnell's* laboratory. Efforts are directed at characterizing the sequence of events in what now appears to be a multistep process of virus-induced transformation and progression to frank leukemia.

The study of biochemical mechanisms involved in the action of interferons to elucidate the early events involved in the interferons-mediated induction of specific cellular genes leading to the development of the antiviral state (and other biological effects), and the manner in which the expression of the cellular genes is regulated is of major importance in *Dr. Gupta's* laboratory.

Studies of the mechanisms of action of interferons against vesicular stomatitis virus, encephalomyocarditis virus, and retroviruses representing three virus groups with completely different replication strategies are underway in *Dr. Sen's* laboratory.

The production and analysis of embryonic lethal mutations and the identification of DNA sequences involved in regulating the stage-specific and tissue-specific expression of genes during mammalian development are the foci of *Dr. Lacy's* research. In the future, her laboratory will attempt a similar study with embryonic and adult alpha-globin genes. She is working collaboratively with Dr. James Darnell's laboratory at Rockefeller University to generate lines of transgenic mice carrying genes specifically transcribed in liver to explore the sequence requirements of this class of genes for correct developmental expression and in order to isolate mutations which disrupt embryogenesis in the mouse.

Research in *Dr. Sheffery's* laboratory is directed at understanding how proteins and DNA interact to form structures that influence gene transcription. Particular effort is devoted to understanding tissue-specific gene expression.

Dr. Melera's laboratory is involved in three major research projects: the first attempts to unravel the response of Chinese hamster lung cells (CHL) to antifolate challenge via the overproduction of two different molecular weight forms of the target enzyme dihydrofolate reductase; the second seeks to understand the role of gene amplification in the establishment of the multidrug-resistant phenotype displayed by CHL cells selected with vincristine; and the third is a study of DNA sequence amplification in human cancer, particularly neuroblastoma.

Current work in *Dr. Neff's* laboratory centers on the regulation of gene expression during the cell cycle of the simple eukaryotic baker's yeast, *Saccharomyces cerevisiae*, with calcium and calmodulin used as signal molecules during the cell cycle.

Recent Publications

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Pharmacology

Faculty

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Research Activities

This joint program, sponsored by faculties of the Field of Pharmacology of the Medical College Division and the Unit of Developmental Therapy and Clinical Investigation of the Sloan-Kettering Division, offers a broad spectrum of training opportunities from the molecular level to whole organism pharmacology.

Dr. W. Y. Chan: This laboratory is interested in the functions and interactions of prostaglandins and neurohypophysial peptides in the kidney and the uterus. Current research covers investigative studies from subcellular levels to the whole

organism. We have found that certain analogs of oxytocin and vasopression stimulate urinary sodium and water excretion. This renal effect of the peptide appears to be mediated by renal prostaglandin release. The biochemical mechanisms of this peptide-induced prostaglandin release is the principal concern of our research. Additionally, we also study the renal activities of peptide analogs specifically synthesized for our project with the aim to discover specific prostaglandin₇ releasing peptides that may be useful for the treatment of renal hypertension.

In the uterus, we are investigating the roles of prostaglandins and oxytocin in the regulation of uterine contractions, especially relating to preterm labor, using the pregnant rat model. The effects of endogenous prostaglandin on the density of oxytocin receptors in myometrial plasma membrane and on the formation of gap-junctions of myometrial cells are determined by radio-ligant receptor binding and by electron microscopy. Highly potent oxytocin antagonists have been synthesized for this project. Their potential in the prevention of preterm labor will be investigated in the pregnant rat model.

Dr. T-C. Chou: The major research objectives of this laboratory are the study of: (1) the mechanisms of action of antitumor and antiviral agents; (2) the biochemical and pharmacological bases for the selectivity of effects on different targets; and (3) the derivation of theoretical formulations for dose-effect relationships that permits the automated computer analysis of relative potency and therapeutic index and facilitates the study of the interaction of multiple drugs in combination chemotherapy. The compounds of current interest include potent antiherpes viral agents, a classical antifolate analog, and a lipid-soluble antifolate. Emphasized are pharmacodynamics, pharmacokinetics and preclinical toxicology, the determination of affinity and efficacy of drug interaction with enzymes or other targets, the elucidation of molecular events following the binding or incorporation of a drug into macromolecules, and the development of computer programs for drug evaluation. Currently several of the compounds mentioned above are in clinical trials. Also, software for dose-effect analysis has recently been developed for microcomputers.

Dr. D. Felsen: Our laboratory is interested in the role of arachidonic acid metabolites (AAMs; prostaglandins, hydroxy acids and leukotrienes) and other mediators of inflammation in renal and hepatic function. We study the role of these compounds both *in vivo* and *in vitro* using a combination of techniques. These include measurement of renal blood flow, both isotopically and non-isotopically, glomerular filtration rate and other parameters of renal function (Na^+ and K^+ excretion, water excretion, etc.). *In vitro*, both isolated organs and cell culture techniques are used for studies of renal and hepatic cells. With these methods, we hope to understand the molecular mechanisms involved in the interaction of AAMs and other inflammatory mediators in different models of renal and hepatic disease.

Dr. J. J. Fox: Design and chemical syntheses of new compounds for evaluation as potential anticancer and/or antiviral agents; chemical syntheses designed to establish structure-activity relationships and/or to provide substrates for collaborative studies on the structural specificity of key enzymes that may be involved in the biological activity of the drugs synthesized. Research efforts are devoted mainly (but not exclusively) to the syntheses of compounds related in structure to nucleic acid components, such as their nucleosides, and to nucleoside antibiotics or to

other naturally-occurring nucleosides bearing purines or pyrimidines or other analogous heterocycles.

Dr. J. Fried: Research in this laboratory focuses in the following areas: (1) Use of flow cytometry and cell sorting for cell cycle analysis, detection of cell surface antigens, and separation of cell types in bone marrow specimens using multiparameter gating; (2) Kinetic and quantitative factors affecting the sensitivity of target cells to lysis using monoclonal antibody and complement. Such factors include antigenic modulation, amount of antibody bound to target antigen molecules, and antibody combinations; (3) Synergistic effects of cytotoxic drugs, and antibody plus complement, on viability of tumor cells in multiple myeloma; Use of these agents for bone marrow purging; (4) Induction of differentiation of lymphocytes to plasma cells in multiple myeloma by TPA and other compounds; (5) Use of myeloma cell lines as experimental models of multiple myeloma.

Dr. C. E. Inturrisi: The objectives of this research are to develop novel methods for the simultaneous quantitation of the precursors and products of endorphin, enkephalin and dynorphin biosynthesis. These methods, which include high performance liquid chromatography, tracer techniques and recombinant DNA technology, are being applied to studies of the role of neurogenic and hormonal factors and the effects of opioid agonist and antagonist drugs on opioid peptide biosynthesis in selected CNS tissues and in the adrenal medulla.

Chronic treatment with opioid antagonists increases opioid binding in the central nervous system of rats and produces an increase in the analgesic activity of morphine. We are examining the functional and molecular consequences of these effects with respect to dosage, strain and species differences, development of tolerance and dependence, and mediation at spinal and supraspinal sites.

Clinical studies are aimed at developing pharmacologic models from patient data that can be used to improve analgesic therapy and provide insight into the quantitative aspects of the development of tolerance to opioids in these patients. We are studying the value of newer opioids, opioid peptides and novel routes of administration in the management of pain in cancer patients.

Dr. R. Levi: The possibility that mediators of inflammation and immune hypersensitivity cause cardiac dysfunction and play a role in the pathogenesis of sudden death, heart attacks, and cardiac failure is under investigation in our laboratory. The molecular bases of the negative inotropic effect of leukotrienes platelet-activating factor and histamine, as well as the electrophysiological and biochemical effects of these mediators are being studied. Further, the relevance of complement activation and anaphylatoxin generation in cardiac hypersensitivity is being investigated. The possible physiological role of endogenous cardiac histamine as a modulator of adrenergic responses is being uncovered. The receptors mediating this histamine-induced modulation are being sought and the molecular mechanisms of this modulation are being assessed.

Dr. M. Okamoto: Current research interests in this laboratory are centered on studies of the pharmacologic and neuropharmacologic bases of the physical dependence and withdrawal caused by general central nervous system depressants. Barbiturates, benzodiazepines and alcohol are the prototype drugs for these studies. A quantitative methodology for the pharmacologic characterization of tolerance and of physical dependence on these CNS depressants in animal models

has been perfected in this laboratory. Ongoing studies involve development of analytical procedures for the determination of sedative-hypnotic drugs and their pharmacologically active metabolites, steroids, biogenic amines, and polypeptides in biofluids; neuroelectrophysiologic and behavioral monitoring of acute and chronic drug actions, investigation of cellular mechanisms for tolerance and physical dependence production and withdrawal hyperexcitation to these drugs.

Dr. B. A. Otter: Research interests of this laboratory are as follows: (1) The synthesis of nucleosides as potential antimetabolites. Specifically, current work centers around the synthesis of purine-like C-nucleosides that are resistant to the degradative effects of nucleoside phosphorylases by virtue of the non-cleavable carbon-carbon anomeric bond. (2) The antitumor activity of pyrimidine derivatives. Certain pyrimidine analogs incorporating a vinyl substituent at C-6 show moderate levels of *in vivo* activity against mouse leukemias. The compounds almost certainly function as alkylating agents, although the mechanism of action remains to be determined. This program is aimed at defining structure-activity relationships. (3) The fundamental properties of inhibitors of nucleic acid synthesis. Studies on the basic chemistry of nucleic acid-related monomers are of considerable importance for improving our understanding of biochemical events at the molecular level. Of special interest is the role of nucleoside conformation in the specificity of enzyme-catalyzed reactions, an area that has not yet been exploited in the development of nucleoside-based drugs.

Dr. G. W. Paternak: Our laboratory studies the biochemical and pharmacological properties of various subclasses of opiate receptors within the central nervous system. Molecular approaches include binding studies and affinity labeling of receptors using a series of irreversible opiate agonists and antagonists developed and synthesized in our laboratory. Our computerized quantitative autoradiographic studies aimed at the distribution of the various subtypes of receptors complement the biochemical studies. In addition to these molecular studies, we also correlate the biochemically defined binding subtypes with specific opiate actions, including analgesia, respiratory depression, gastrointestinal motility and hormone modulation, using classical pharmacological techniques. Again, the selective affinity labels developed in our laboratory have proven invaluable in these studies.

Dr. M. M. Reidenberg: One of the major questions in clinical pharmacology is: Why do different people react differently to the same dose of the same drug? Our program in clinical pharmacology addresses this question in a number of ways. We have learned how genetically controlled rates of drug metabolism alter dose-response. We have systematically studied how decreasing kidney function modifies drug action. The information gained from these studies has been incorporated into the mainstream of medicine and therapeutics.

A class of patients who appear to have a high frequency of adverse drug reactions and for whom only limited knowledge about drug response exists is the elderly. This group is our current focus of interest since we think systemic study of drug action in the elderly will produce knowledge that will improve therapeutics for this group of patients. Specific studies to learn about how aging affects drug metabolism, drug excretion and tissue sensitivity to drugs are done to gain information that can then be used to individualize therapy for elderly people as well as shed light on the process of aging itself.

Dr. A. B. Rifkind: Our laboratory is investigating the biochemical changes by which polychlorinated biphenyls, dioxins and chemically related compounds (poly-halogenated aromatic hydrocarbons, or PAH) lead to tissue injury and death. We are interested in PAH action with respect to both the mechanisms of toxicity and the regulation of gene expression. We are using a chick embryo model as our primary system and the incidence of mortality, subcutaneous and pericardial edema formation, loss of thymus weight and impaired cardiac contractile responses to catecholamines, as indices of toxicity. It has been established that toxic PAH congeners activate the Ah receptor which, in turn, controls the expression of a group of gene products including a form of cytochrome P-450 known as cytochrome P-448. Evidence from our laboratory and others indicates that induction of hepatic cytochrome P-448 mediated mixed function oxidase activity regularly accompanies PAH toxicity but does not cause the toxicity. We are currently investigating (1) the relationship of changes in extrahepatic mixed function oxidase activity to toxic changes; (2) effects of PAH on arachidonic acid metabolism and how those changes relate to toxicity; and (3) the biochemical changes accompanying the decreased cardiac contractile response to catecholamines produced by PAH treatment of the chick embryo.

Dr. F. M. Sirotnak: Our research focuses on (1) molecular targets and other cellular biochemical determinants important to selective antitumor action of various categories of cytotoxic antimetabolites; (2) cytoplasmic membrane transport of pharmacologic agents; (3) molecular mechanisms of acquired resistance of tumor cells to antineoplastic agents; and (4) the regulation of folate and nucleoside transporter gene expression.

Folates play a crucial role in the biosynthesis of macromolecules. Access of tumor cells to exogenous plasma folate is made possible by the existence in the cytoplasmic membrane of a specific high-affinity transport system.

Using c-DNA probes, the genetic regulation and molecular biology of this system are now being examined in models which constitutively over-produce or under-produce the transport protein and during induction of tumor cells to terminal maturation.

Folate and nucleoside analogs effectively accumulate in tumor cells via plasma membrane systems normally transporting natural folates and nucleosides. Toward our understanding of the selective antitumor action of folate and nucleoside analogs, we are examining the properties and multiplicity of their cellular membrane transport, their interaction with enzymic and macromolecular targets, their intracellular metabolic disposition and their pharmacokinetic behavior. Mechanisms of acquired resistance in tumor cells to these antimetabolites and other cytotoxic agents at the level of their cellular membrane transport are also studied by the investigation of alterations.

Dr. H. H. Szeto: Our laboratory is interested in studying the effects of prenatal drug exposure on the development of the central nervous system. We are particularly interested in the development of sleep-wake behavior and the regulation of breathing in the fetus and neonate. As such investigations cannot be carried out in human, we are using the fetal lamb as an animal model. Using techniques that permit continuous intrauterine recording of fetal electrocortical activity, eye movements, postural muscle activity, and diaphragmatic activity, we have found that acute

prenatal exposure to opiates and benzodiazepines can alter fetal behavioral and breathing activity. We are now examining the effects of chronic opiate exposure on the maturation of sleep-wake behavior and respiration control.

We are also studying the effects of maternal marijuana smoking on the fetus by introducing marijuana smoke into the maternal trachea and monitoring its effects on maternal and fetal neurobehavior, hemodynamics, metabolism and hormonal regulation.

In addition, we have used a variety of pharmacologic agents to investigate the role of various neurotransmitters and neuromodulators that may potentially be involved in the regulation of sleep-wake behavior and respiratory control in the fetus.

Dr. K. A. Watanabe: We are interested in synthetic photochemistry to enzyme reaction mechanisms. Major emphasis is on the chemical design and development of better anticancer and antiviral agents which interfere with selective DNA metabolism. On the basis of a biological and biochemical rationale, various sites on the molecules of natural substances and synthetic derivatives with biological activities are chemically modified so that these new molecules may inhibit specific enzyme reaction(s). Our recent discoveries of novel carbohydrate reactions have resulted in the development of potent antiviral N-nucleosides. The novel heterocyclic chemistry discovered in our laboratory has been employed in the development of C-nucleosides with potent anticancer activity. Also, our heterocyclic reactions have been applied to the preparation of anticancer antifolates. We have also proposed plausible mechanisms of action for tryptophan oxidizing enzyme and cytidine deaminase, on the basis of studies using simple chemically modified substrates.

Recent Publications

- Chan, W. Y., Uterine and placental prostaglandins and their modulation of oxytocin sensitivity and contractility in the parturient uterus. *Biol. Reprod.* 29:680-688, 1983.
- Chan, W. Y. (with Powell, A. M., Alvine, P., and Litt, I. F.), Menstrual PFG₂ α , PGE₂ and TXA₂ in normal and dysmenorrheic women and their temporal relationship to dysmenorrhea. *Prostaglandins* 29:273-290, 1985.
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- Okamoto, M., Barbiturate tolerance and physical dependence: Contribution of pharmacological factors. In: *Mechanisms of Tolerance and Dependence*. NIDA Research Monograph Series 54:333-347, 1985.
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- Watanabe, K. A. (with Su, T-L., Pankiewicz, K. W., and Harada, C.), Novel ring transformation reactions and their applications to the synthesis of potential anticancer heterocyclic compounds. *Heterocycles* 21:289-307, 1984.

Requirements and Course Offerings

Admission

Applications

For admission to the Graduate School of Medical Sciences an applicant must (1) have a baccalaureate degree or the equivalent from a college or university of recognized standing, (2) have adequate preparation in the chosen field of study, and (3) show promise of ability to pursue advanced study and research, as judged by his or her previous record.

Inquiries about graduate study should be addressed to the Associate Dean of the Graduate School of Medical Sciences, 1300 York Avenue, New York, NY 10021 or to the Associate Director of the Sloan-Kettering Division, 1275 York Avenue, New York, NY 10021.

Candidates may be admitted in September, February, or July, although places in the graduate program for February and July may not be available because of prior commitments to applicants for September admission. Applicants for February or July admission should correspond directly with the respective Field Director in the Medical College Division or the Associate Director of the Sloan-Kettering Division regarding the availability of places.

Application material must be completed and returned to the Office of the Graduate School of Medical Sciences together with (1) official transcripts of records from all colleges and universities attended, (2) a statement of purpose of graduate study, and (3) two letters of recommendation from individuals in academic positions who know the applicant professionally. In addition, scores from the Graduate Record Examinations (GRE) are usually required to aid in the evaluation of an applicant. Application for taking the Aptitude (Verbal, Quantitative, and Analytical) Test and the Advanced Test of the GRE, must be made directly to the

Educational Testing Service
Graduate Record Examinations
Box 955
Princeton, NJ 08541

The proper Institution Code Number to use in your GRE application for the Cornell

University Graduate School of Medical Sciences (New York City) is R 2119-6.

Applications for September or July admission and all credentials, including official transcripts of records from all colleges and universities attended, must be received by the deadline of March 1.

Applications and credentials for February admission must be received by November 1.

Application fee. A nonrefundable charge of \$35 is made for filing an application for admission.

The completed application and all supporting documents are initially screened by the credentials committee of the program to which the student is applying. Applicants who are considered potentially acceptable are usually called for a personal interview. At the time of interview, after discussing his or her interests with the members of the Field or Unit, the applicant may tentatively select a major sponsor. If accepted by the Field or Unit, an application is forwarded to the interdivisional Credentials Review Committee and then to the Dean for final decision. A student is formally notified of acceptance for study in the Graduate School of Medical Sciences by a letter from the Dean. An applicant accepted for admission is requested to inform the Graduate School of Medical Sciences of her or his plan to either accept or refuse the offer of admission within one month after the Dean's acceptance letter has been received.

It is the policy of Cornell University to actively support equality of educational and employment opportunity. No person shall be denied admission to any educational program or activity or be denied employment on the basis of any legally prohibited discrimination involving, but not limited to, such factors as race, color, creed, religion, national or ethnic origin, sex, age, or handicap. The University is committed to the maintenance of affirmative action programs which will assure the continuation of such equality of opportunity.

Admission policies are also in conformity with the policy of New York State in regard to the American ideal of equality of opportunity as embodied in the Education Practices Act.

Categories

An applicant is accepted by the Graduate School of Medical Sciences (1) as a degree candidate for the M.S. or Ph.D., or (2) as a provisional candidate.

Provisional candidacy provides opportunity for a prospective degree candidate, whose educational preparation is difficult to evaluate, to begin graduate studies. On the basis of the record of accomplishment in the first half of the academic year, the adviser or temporary Special Committee of a provisional candidate may recommend to the Dean that (1) provisional candidacy be changed to degree candidacy, (2) provisional candidacy be continued for the remainder of the academic year, or (3) provisional candidacy be terminated. A maximum of one academic year in the status of provisional candidacy is permitted and credit of a maximum of one residence unit may be allowed on petition, provided there is convincing evidence that performance has been of the same quality as that required of degree candidates.

Special Students

Special students are students who are not degree candidates in either the Graduate School of Medical Sciences or the Medical College and who are given permission by the respective dean to take courses at either school. Special students must be degree candidates at other institutions and the courses taken at Cornell must be essential to their degree programs and are not offered by the institutions at which they are matriculated as degree candidates as certified by the institutions. Enrollment as a special student is not intended as preparation for admission to degree programs at Cornell or elsewhere.

In the case of the Graduate School of Medical Sciences, special students are accepted only with the approval of the appropriate Field Director in the Medical College Division or of the appropriate Chairperson in the Sloan-Kettering Division. Special students must demonstrate special qualifications in terms of preparation and ability. They must register with the Graduate School of Medical Sciences or in the Medical College and must pay all tuition and fees before being permitted to attend lectures or laboratory sessions. Tuition is

computed on the basis of the ratio of course hours taken to the total hours of instruction for the academic year (33 weeks of 40 hours). There is a registration fee of \$35.

Degree Requirements

Major and Minor Fields*

A candidate for the degree of Master of Science is required to register for study in one major and one minor field. Each field decides whether the Special Committee of a candidate for the Ph.D. degree must have two or three fields represented. Accordingly, a candidate for the degree of Doctor of Philosophy is required to register for study in one major and one or two minor fields. At least one of the minors must be outside the area of the major field.

The Special Committee

The general degree requirements of the Graduate School of Medical Sciences are minimal in order to give maximum flexibility in choosing a desirable program of study. The student's program is determined with the aid and direction of a Special Committee, consisting of at least three faculty members chosen by the student from those fields that best fit his or her areas of interest. Satisfactory progress toward a degree is judged by the committee rather than by arbitrary standards imposed by the Graduate School of Medical Sciences. There are no regulations of the Faculty of the Graduate School of Medical Sciences governing the specific content of instruction, courses, or grades to which the Special Committee must subscribe, except those imposed by the fields. The committee is primarily responsible for the candidate's development as an independent scholar and scientist.

No later than four weeks after enrollment, a candidate must file a statement of the major and minor fields elected for

*Areas of concentration towards a degree at the Cornell University Graduate School of Medical Sciences are referred to as *Fields* in the Medical College Division and as *Units* in the Sloan-Kettering Division. Both these terms, as well as the Interdivisional Programs, are intended to be covered by the term *field* in this and subsequent sections.

study, after which the student must choose faculty members to represent the fields and to serve on a Special Committee. The major sponsor usually advises the student concerning the other selections and chairs the committee. At least one member of the committee must represent a field different from the candidate's major field. Members may agree to serve temporarily during the candidate's first year of residence until the candidate has had the opportunity to become acquainted with areas of research in the fields of his or her choice. On completion of this year of residence, a permanent Special Committee will be formed, the membership of which can be changed with agreement of all members of the old and newly formed committees and the approval of the Dean. The members of the Special Committee decide on the student's program of study and research, and judge whether progress toward a degree is satisfactory. After consulting the other members, the chairperson of the Special Committee prepares term reports on the candidate for submission to the Dean. The members of the committee serve on all the candidate's examining committees and they approve his or her thesis.

Registration and Course Grades

No student in the Graduate School of Medical Sciences may double-register for an advanced general or professional degree with any other school or college except the Cornell University Medical College.

At the beginning of each term, students are required to register with the Office of the Graduate School of Medical Sciences and to file a registration of courses form indicating all courses they will take. A fee of \$10 is charged for late registration.

At the beginning of each course in which the student is enrolling, the student will complete a separate course registration form for the instructor. All courses for which the student registers for credit will be entered in the official record. Grades of graduate students are reported as: Excellent (E), Satisfactory (S), Unsatisfactory (U), Incomplete (I), Absent (Abs.), or Unofficially Withdrawn (W). A grade of Incomplete or Absent cannot be changed later than one term following the one in which the course was taken.

Registration for the summer is required of graduate students who will be engaged in research.

Residence

The Faculty of the Graduate School of Medical Sciences regards study in residence as essential. Each candidate for an advanced general degree is expected to complete the residence requirements with reasonable continuity. A student must register each term from the time of his or her first registration in the Graduate School of Medical Sciences until the student either withdraws or completes a degree (unless a leave of absence has been granted). Full-time study for one-half academic year with satisfactory accomplishment constitutes one residence unit. Two units of residence are the minimal requirement for the master's degree and six units are the minimum for the doctoral degree. However, the time necessary to obtain the degree generally exceeds the minimal requirements. A candidate for the Ph.D. degree must spend two of the last four units of required residence in successive terms on the New York City or the Ithaca campus of Cornell University. No more than seven years may intervene between the time of first registration and the completion of all requirements for the doctoral degree. A student must complete all requirements for the master's degree in four years.

Part-time graduate study, if it is necessitated by off-campus employment noncontributory to the major field of study, is not encouraged. Requests for part-time study must be reviewed by the Executive Committee. If permission is granted for part-time study, the student must be in residence at least half-time.

The legislation with respect to eligibility of part-time students for residence units is as follows:

Employment	Residence Units Allowable Per Half Academic Year		
<i>Total clock hours per week</i>	<i>Contributory in major field; on campus</i>	<i>Noncontributory; on campus</i>	<i>Off Campus</i>
0-10 hours	1 unit	1 unit	$\frac{3}{4}$ unit
11-20 hours	1 unit	$\frac{3}{4}$ unit	$\frac{3}{4}$ unit
21-30 hours	$\frac{3}{4}$ unit (teaching) $\frac{3}{4}$ -1 unit (research)*	$\frac{1}{2}$ unit	—

*Time spent assisting in research, if it is contributory to the major field of study, shall be credited toward allowance of a full residence unit.

Transfer of Residence Credit

No residence credit will be granted for study outside the Graduate School of Medical Sciences to fulfill the requirements of the M.S. degree. No commitment can be made about granting residence credit toward the Ph.D. requirements for previous study in another graduate school until after the candidate has entered into residence at the Graduate School of Medical Sciences. At that time, the student's Special Committee may recommend acceptance of study outside the Graduate School of Medical Sciences to the Executive Committee, which will determine the number of residence units to be awarded. No credit can be transferred for study undertaken as an undergraduate or as a special student even in courses designed for graduate students.

A student who has satisfactorily completed two or more academic years of study toward the degree of M.D. at the Cornell University Medical College, or another accredited medical school in the United States with a curriculum equivalent to that of the Cornell University Medical College, may transfer a maximum of two units of residence credit after passing an evaluation examination administered by a committee appointed by the Executive Committee of the Graduate School of Medical Sciences.

Summer Research

Registration is required for the summer research term whether or not this effort will be credited toward residence unit accumulation. Students registered for summer research pay prorated tuition only

if they are obtaining residence credit. However, no degree candidate is eligible for more than two residence units in any period of twelve consecutive months.

Study *In Absentia*

A candidate for the degree of Doctor of Philosophy may petition for permission to earn residence units for study away from Cornell University while regularly registered in the Graduate School of Medical Sciences. A candidate to whom this privilege has been granted, must register as a Candidate *in absentia* and may work temporarily under the immediate supervision of an individual designated by his or her Special Committee although the candidate's program will continue to be directed by the Committee. For study *in absentia*, not more than two residence units may be earned toward fulfillment of the minimal residence requirements for the Ph.D. degree.

Leave of Absence

A candidate who finds it necessary to interrupt the continuity of his or her residence must petition the Dean for an official leave of absence. This written petition must specify the term of absence, state the reason for the requested leave of absence, and be approved by the student's Special Committee.

A student who will *not* be in residence but will return to the Graduate School of Medical Sciences to present and defend a thesis at the final examination, having completed all requirements for a degree except for the final examination, *must* petition for a leave of absence.

Examinations

Three examinations are required by the Faculty of the Graduate School of Medical Sciences: (1) Final Examination for the M.S. degree, (2) Examination for Admission to Doctoral Candidacy, and (3) Final Examination for the Ph.D. degree. Examinations are administered by an Examining Committee consisting of a chairperson appointed by the Dean, the members of the candidate's Special Committee, and, in the case of the Admission to Doctoral Candidacy Examination, three additional members selected from the Faculty of the Graduate School of Medical Sciences and/or of other institutions. In addition to these examinations, the candidate's major field may require a qualifying examination as part of its evaluation of the candidate after two units of residence have been completed.

For the M.S. degree: The Final Examination may be oral or both oral and written.

For the Ph.D. degree: The Admission to Doctoral Candidacy Examination is both oral and written and certifies that the student is eligible to present a thesis to the Faculty of the Graduate School of Medical Sciences. The examination should be taken after course work is largely finished but before significant thesis research has begun. Accordingly, the usual examination time will be at the end of the second year of residence. The examination may not be taken until two units of residence credit have been accumulated and a minimum of two units of residence credit is required after passing this examination before the final examination can be scheduled. The final examination for the Ph.D. degree is an oral defense of the candidate's thesis. It must be passed within four years after completion of the required residence units, or within seven years from the date of first registration, whichever is earlier.

Foreign Language Requirements

Each field of study has its own foreign language requirements. The student's Special Committee may require knowledge of foreign languages beyond the requirements of the fields listed in this *Announcement*.

Arrangements for a foreign language examination will be made on application to

the Office of the Dean. As an alternative to this examination, the candidate may demonstrate proficiency by having passed the reading part of the language qualification tests administered by the College Entrance Examination Board.

Thesis

A principal requirement for both the M.S. and the Ph.D. degrees is the presentation of a thesis constituting an imaginative contribution to knowledge. Ordinarily, the thesis is written on a research topic in the candidate's major field of study, under the direction of the chairperson of his or her Special Committee. The faculty requires that the Ph.D. thesis be published in abstract and be recorded on microfilm.

Tuition and Fees

Tuition

Tuition for a student regularly matriculated in the Graduate School of Medical Sciences is \$10,950 for the academic year 1986-87 and is payable in two equal parts, the first of which is due at initial registration. Tuition includes fees for matriculation, hospitalization insurance, graduation, and miscellaneous thesis expenses.

For students who (1) have been in continuous residence at Cornell in the same doctoral program and have accumulated four units of residence credit, (2) have passed their Admission to Doctoral Candidacy Examination, and (3) are not taking courses in the Medical College curriculum, a reduced charge of \$1800 per annum (\$900 per semester) will be made for tuition and fees for the terms subsequent to the Admission to Doctoral Candidacy Examination. For those students who are accepted in the Ph.D.-M.D. Program (see p. 4) and will continue to take courses in the medical curriculum, an additional tuition charge, based on the Medical College tuition (\$15,554 per annum), will be made for the medical course hours taken.

A student who is to receive partial residence credit (see p. 67) because of employment should apply for proration of tuition on forms obtainable at the Office of the Dean. Proration of tuition does not apply to the special reduced tuition of \$900 per semester.

Other Fees

In Absentia A student registered *in absentia* pays a fee of \$200 each term and may continue hospitalization insurance by payment of the annual premium directly to the Student Accounting Office. If students *in absentia* take advantage of local privileges, such as the use of the library, desk space, Student Health Service, and Cornell housing, the fee is \$400 per semester. The latter fee also covers hospitalization insurance.

Leave of Absence Students on leave of absence will be required to pay an active-file fee of \$200 for each semester, up to a maximum of six semesters, during which they are not registered with the Graduate School. This fee will not be subject to finance charges but must be paid before the student can receive an advanced degree. Petition for waiver of this fee will be considered for students who have not completed the required number of residence units.

Candidate for Degree Only A graduate student who has previously fulfilled all other degree requirements, who has been granted a leave of absence, and then returns to the Graduate School of Medical Sciences to present a thesis and to take the final examination must register as a Candidate for Degree Only and pay a fee of \$35.

Any individual who owes money to the University will not be allowed to register or reregister in the University, receive a transcript of his or her record, have his or her academic credits certified, be granted a leave of absence, or have a degree conferred.

The amount, time, and manner of payment of tuition, fees, or other charges may be changed at any time without notice.

Refunds

Part of the *personally* paid tuition will be refunded if the student obtains official certification of leave of absence or withdrawal from the Graduate School of Medical Sciences during the semester. Students who terminate their registration during a regular term in this manner will be charged tuition from the registration day to the effective date of the certificate as follows: first week,

10 percent; second week, 20 percent; third week, 30 percent; fourth week, 40 percent; fifth week, 60 percent; sixth week, 80 percent; seventh week, 100 percent. No charge will be made if the effective date of leave or withdrawal is within the first six days of the term, including registration day.

Financial Assistance

All applicants to the Graduate School are requested to submit a Graduate and Professional School Financial Aid Service (GAPSFAS) form providing an estimate of financial need. The information will be used in two ways: The number of students with documentable need will allow the University to obtain maximum federal funding for loans and work-study purposes, and the specific need of an applicant *may* be used to determine that individual's graduate support. Please obtain the necessary form, available at your college or university financial aid office and from the Educational Testing Service. File the form with the Educational Testing Service, Box 2614, Princeton, New Jersey 08541, and request that the information be sent to Cornell-Code 2267.

Financial assistance is available to qualified applicants. Individual fields may offer predoctoral research fellowships, research assistantships, or teaching assistantships. These positions may provide a stipend in addition to tuition. Information about these positions may be obtained directly from the Field or Unit at the time of application.

Nationwide competitive predoctoral fellowships are available from the National Science Foundation and the National Research Council. Information about these fellowships should be requested directly from the appropriate governmental agency.

New York State residents are eligible for several predoctoral fellowships and the Tuition Assistance Program, which assists in tuition payments. Application forms may be obtained from the New York Higher Education Services Corporation, Student Financial Aid Section, Tower Building, Empire State Plaza, Albany, NY 12255.

Several loan programs are available to graduate students. Under these programs, repayment of the principal amount of the loan together with the interest on the loan may be deferred until after graduation. Complete information regarding loan

programs may be obtained from the Graduate School Office.

Opportunity for part-time employment is often available in departmental research projects or other activities. Applications should be made directly to individual departments.

The Graduate School of Medical Sciences participates in the Work-Study Program of Cornell University which provides a significant salary contribution for qualified employed students.

Scholarships and Fellowships

Full fellowships are provided for graduate students by both the Medical College and Sloan-Kettering Divisions of the Graduate School of Medical Sciences. Recipients of this award become Ph.D. Fellows and will receive a full tuition scholarship and a stipend covering living expenses.

A number of tuition scholarships are available for students in the Medical College Division who are not covered by one of the above fellowships. This scholarship fund is administered by the Office of the Dean of the Graduate School of Medical Sciences.

In addition, the following named funds provide support for selected students:

The Vincent Astor Scholarship Fund. Funds for tuition assistance are also derived from the income from a generous gift by the Vincent Astor Foundation to the Graduate School of Medical Sciences and to the Medical College. Allocation of these funds for graduate student tuition assistance is made at the discretion of the Dean of the Graduate School of Medical Sciences.

The Harry E. Gould, Sr., Medical and Graduate Student Scholarship. This fund was established by Mr. Gould's son, Harry E. Gould, Jr., in memory of his father, a prominent business and civic leader in the City of New York, who had a long-standing interest in medicine. The income from this endowment provides financial assistance for students of the Medical College and Graduate School of Medical Sciences.

The Mildred and Emil Holland Scholarship. Income from a gift by the Emil and Mildred Holland Philanthropic Fund of the

Jewish Communal Fund is used to provide tuition support for an M.D.-Ph.D. student.

The W. A. Keck Foundation Medical Scientist Fellowship. This award is derived from a generous endowment awarded to Cornell University Medical College and provides support for an M.D.-Ph.D. student.

The Francis L. Loeb Medical Scientist Fellowships. These fellowships have been endowed by a gift from Francis L. Loeb and provide support for two M.D.-Ph.D. students at the Cornell University Medical College.

The Frank R. and Blanche A. Mowrer Memorial Fund. Financial assistance is available from the income of this fund to one student each year enrolled in the Ph.D.-M.D. or M.D.-Ph.D. program.

The Papanicolaou Medical Scientist Fellowship is funded by income from a bequest from Mary G. Papanicolaou in memory of her husband, Dr. George N. Papanicolaou, and by a gift from an anonymous donor to the Cornell University Medical College. The funds provide support for an M.D.-Ph.D. student.

The Abby Rockefeller Mauzé Medical Scientist Fellowship was established by a gift from the Abby Rockefeller Mauzé Trust. The income provides fellowship support for an M.D.-Ph.D. student.

The Surdna Foundation Medical Scientist Fellowship was made possible by a generous grant to the Medical College by the Surdna Foundation. The income from this endowment provides fellowship support for an M.D.-Ph.D. student.

Awards and Prizes

The Julian R. Rachele Prize. The income of a fund established by Dr. Julian R. Rachele, former Dean of the Cornell University Graduate School of Medical Sciences, provides for an annual prize to be awarded to a candidate for the Ph.D. degree for a research paper of which the candidate is the sole or the senior author.

Recipient of the prize in 1986 was Beatrice Knudsen.

The Vincent duVigneaud Prizes for the presentation of outstanding papers by students of the Cornell University Graduate School of Medical Sciences at the Annual Vincent duVigneaud Memorial Research Symposium.

Recipients of these awards in 1986 were Alice Brock, Deborah L. Jenkins, Rose Shaffer, and Mark Underwood.

The Frank Lappin Horsfall Jr. Award is endowed by funds provided in memory of Dr. Horsfall by his many friends and family. It is continued evidence of his concern for students manifest during his directorship of the Sloan-Kettering Division.

The award is made annually to a student of the Sloan-Kettering Division, who in the opinion of the Committee of the Faculty of the Sloan-Kettering Division, has been most distinguished, especially in the Admission to Doctoral Candidacy Examination.

Recipient of the award in 1986 was Madge Kanter.

The Thesis Prizes are awarded to students of the Medical College Division who have presented an outstanding thesis during the academic year.

Recipients of these prizes in 1985-86 were Deborah Klein and William Lee.

Student Health Services

The Student Health Plan of Cornell University Medical College provides hospitalization and major medical insurance for all registered graduate students. In addition, the Plan provides for ambulatory care at the Personnel Health Service of The New York Hospital-Cornell Medical Center. Physicians at the Health Service will refer students who require specialized care to clinics of the Hospital and to attending physicians of the staff.

The cost of medical services provided by the Plan are included in the tuition and fee structure announced by the Graduate School of Medical Sciences each academic year. Students will be issued Plan membership cards and will receive courtesy privileges at The New York Hospital Pharmacy.

Entering students are requested to have a physical examination, chest X-ray and laboratory tests performed by their personal physicians prior to matriculation. The hours of the Personnel Health Service and a

complete statement of Plan benefits will be provided to each graduate student.

It is recommended that students purchase insurance coverage for eligible dependents who do not have other insurance available to them. Insured dependents are not eligible for care at the Personnel Health Service but they will be referred to appropriate members of the Hospital staff for medical treatment.

A student studying *in absentia* may continue hospitalization insurance by payment of the annual fees directly to the Student Accounting Office.

A student on leave of absence is not eligible to receive student health benefits.

Residence Halls

F. W. Olin Hall, a student residence, is at 445 East Sixty-ninth Street directly across from the Medical College entrance on York Avenue. Olin Hall contains a gymnasium, lounges, and 245 residence rooms. Each residence room is a single bedroom-study, but since two rooms share a connecting bath, they may be used as a suite for two students. The rooms are completely furnished. The student housing fee is \$202 per month.

Livingston Farrand Apartments, also located on East Sixty-ninth Street, just beyond Olin Hall, have furnished apartments of 1½, 2, 3, and 4 rooms. Cooking facilities are provided in these apartments. Housing fees range from \$258-\$476 per month (utilities not included). These apartments are available to married and upper-class students.

Jacob S. Lasdon House, an apartment residence, is located at 420 East Seventieth Street. This building contains studio, one-bedroom, and two-bedroom apartments and two squash courts. Apartments are fully furnished and include kitchens. Housing fees range from \$437-\$800 per month including utilities. Single, first-year students cannot be accommodated in this building.

The fees listed above may be changed at any time without previous notice.

Special Programs

Application to the Medical Scientist Training Program (M.D.-Ph.D.)

Successful applicants must demonstrate a strong undergraduate science preparation, and an early commitment to a career combining both clinical and laboratory research. They must simultaneously satisfy the separate requirements for admission to Cornell University Medical College and to the Divisions of the Graduate School of Medical Sciences.

Applications must show whether admission is sought to the M.D.-Ph.D. program of the Medical College Division, the Sloan-Kettering Division, or both (see p. 3 for a description of the programs). Only one set of documents is required for applications to either or both programs. All documents must be forwarded to the *Office of Admissions, Cornell University Medical College, 445 East 69th Street, New York, NY 10021*. (Telephone 212, 472-5673).

The following items are required, by November 30, for an application to be considered complete:

1. *AMCAS application.* (The personal data and academic record presented in this application are suitable for evaluation by both the medical and graduate schools.)
2. *Supplemental Information Form.* This form will be supplied when further information is requested.
3. *Test Scores.* MCAT scores are required; GRE scores are optional. If the GRE is taken, please instruct the Educational Testing Service to forward your scores.
4. *Personal statement.* A summary of the applicant's background, interests, and reasons for pursuing the combined program.
5. *Letters of Recommendation.*
 - a. Evaluation by the pre-medical advisory committee or two letters from members of the undergraduate science faculty addressing themselves to the applicant's suitability for a career in medicine.
 - b. Evaluations by at least two faculty members addressing themselves to the applicant's research potential.
6. *Application Fee.* After the AMCAS application is received, a check for \$45 is

requested to cover the application processing fee.

After screening, selected applicants to the program will be invited to visit the Cornell Medical Center and meet with members of the faculty of the medical and graduate programs. These interview visits will be coordinated by the Medical College Admissions Office.

Application to the Ph.D.-M.D. Program

Applications to this program (see p. 4 for description) are ordinarily made after the completion of the first year of study in the Graduate School of Medical Sciences, although more advanced students may be considered. The deadline for application is February 1.

To apply, the student must submit to the Office of the Dean of the Graduate School of Medical Sciences:

1. A completed application for admission with advanced standing to Cornell University Medical College (obtainable from the Medical College Admissions Office).
2. A plan of graduate study incorporating all required course work of the first two years of the Medical College curriculum and endorsed by the student's Special Committee.
3. Evidence of successful completion of at least two major medical school basic science courses (anatomical sciences, biochemistry, microbiology, pathology, pharmacology, physiology).
4. Two letters of evaluation from faculty of the Graduate School of Medical Sciences.

The Office of the Dean of the Graduate School of Medical Sciences will review the student's credentials and make a recommendation to the Committee on Admissions of Cornell University Medical College. Only applicants who are found to be acceptable by this committee, after review of the application and personal interviews,

can enter the Ph.D.-M.D. Program. Final decision will be made before June 1.

Students in this program must meet the following requirements before admission to the third-year clinical curriculum of the Medical College:

1. Complete all required graduate courses and the remainder of the first two years of the medical school curriculum.
2. Pass the Admission to Doctoral Candidacy Examination, required by the Graduate School of Medical Sciences.
3. Complete the dissertation research; present and successfully defend an original thesis at the final examination for the Ph.D. degree.

After satisfactory fulfillment of the required clinical rotations of the Cornell third-year medical school curriculum, these students may receive credit for their graduate studies to satisfy the elective requirements of the fourth-year medical school curriculum and will then be recommended for award of the M.D. degree by Cornell University.

While registered as a graduate student in the Ph.D.-M.D. Program, the student is subject to the tuition schedule of the Graduate School of Medical Sciences. Upon completion of the requirements for the Ph.D. degree, the student is registered in the Medical College and is subject to its tuition schedule.

Instruction at the Medical College Division

Field of Biochemistry

Field Director

A. Meister, Department of Biochemistry,
Room E-106, Medical College, (212) 472-
6212

Faculty Representative

D. Wellner, Department of Biochemistry,
Room E-219, Medical College, (212) 472-
6197

Graduate instruction is offered leading to the Ph.D. degree. Within the framework of degree requirements and in consultation with the student, the course of study is planned to fit the need of the individual. Although formal course work is required, emphasis is placed on research. Research opportunities exist in various areas of biochemistry including enzymology, structure and function of proteins and nucleic acids, molecular biology, physical biochemistry, and the intermediary metabolism of amino acids, carbohydrates, nucleic acids, and lipids. Entering graduate students usually work for short periods in several of the laboratories of the faculty members of the Field before beginning their thesis research. Students are encouraged to choose challenging fundamental research problems that are on the frontiers of biochemistry.

The laboratories of the faculty members are equipped with virtually all of the instruments and facilities required for modern biochemical research; thus, graduate students are instructed in such methodology as chromatography, countercurrent distribution, radioactive and stable isotope techniques, spectrophotometry, electrophoresis, and analytical ultracentrifugation.

Students who undertake graduate study in biochemistry must have a sufficiently comprehensive background in chemistry to pursue the proposed course of study and must present evidence of knowledge of biology, general experimental physics, mathematics (including differential and integral calculus). Students may remedy

deficiencies in these areas during the first year of graduate study. The Graduate Record Examination (the aptitude test and the advanced test in chemistry) is ordinarily required.

The student is required to demonstrate proficiency in one modern foreign language acceptable to the student's Special Committee. Proficiency in a computer programming language, as demonstrated by executing a meaningful program, may substitute for proficiency in a foreign language.

Courses

Graduate Biochemistry Offered jointly by the faculties of the Medical College and Sloan-Kettering Divisions. This course is designed to provide the student with a knowledge of the fundamentals of biochemistry and an appreciation of the molecular basis of biological phenomena. Graduate students in the Field of Biochemistry are required to pass this course (or its equivalent). First and second quarters. Dr. Haschemeyer.

Advanced Biochemistry This course consists of one or more lecture series (minicourses) covering selected areas of current interest at an advanced level. The topics change from year to year and may be repeated after 2 or 3 years. The subjects offered include: 1) nucleic acids and protein synthesis; 2) intermediate metabolism and its regulation; 3) kinetics and enzyme mechanisms; 4) protein and peptide microchemistry; 5) membrane structure and function; 6) hormones; 7) computer programming for the biochemist; 8) physical methods in the study of macromolecular and cellular structure; 9) design of inhibitors of enzymes and transport systems. Prerequisite: Graduate Biochemistry. Courses offered in 1986-87:

Molecular Biology of Nucleic Acid-Protein Interactions. Fourth quarter 1986-87. Dr. Lockard.

Biosynthesis, Processing, and Intracellular Transport of Proteins. Fourth quarter 1986-87. Dr. Tate.

Membrane Biochemistry Fourth quarter 1986-87. Dr. Hajjar.

Design of Inhibitors of Enzymes and Transport Systems Second and third quarters 1986-87. Dr. Griffith.

Other Academic Offerings

Introduction to Research Laboratory rotations in experimental biochemistry dealing with the isolation, synthesis, and

analysis of substances of biochemical importance (enzymes, co-enzymes, various metabolites and intermediates), and study of their properties by various chemical and physical techniques. The student obtains this varied research experience by spending approximately two months in the laboratory of each of four faculty members of his or her choice. For incoming graduate students majoring in biochemistry.

Biochemistry Seminars A seminar series in which students, faculty, and invited scientists from this and other institutions report on progress in their laboratories.

Field of Cell Biology and Genetics

Field Director

D. A. Fischman, Department of Cell Biology and Anatomy, Room E-116, Medical College, (212) 472-6400

Faculty Representative

J. L. German III, New York Blood Center, 310 E. 67 St., New York, NY 10021, (212) 570-3075

The Field of Cell Biology and Genetics offers a program of advanced study leading to the Ph.D. degree. The program is intended to prepare students for a career in basic research and teaching in cell, developmental and molecular biology, genetics, anatomical sciences, or related health sciences. Administration of the Field is based in the Department of Cell Biology and Anatomy in a recently renovated research wing of Cornell University Medical College. Additional laboratories are located in various departments of Cornell University Medical College, the Sloan-Kettering Institute, and the New York Blood Center.

For graduate study in the field, adequate undergraduate preparation in biology, chemistry (including organic chemistry), physics, and mathematics is recommended. Requirements for admission are flexible in

proportion to the promise and accomplishments of the applicant. Applicants are requested to present results of the Graduate Record Examination.

Requirements for minor sponsorship in the field will be arranged with individual students, but research experience in the minor sponsor's laboratory is strongly encouraged.

Students are generally required to take Cell Biology and Microscopic Anatomy and at least three of the more advanced courses in genetics, molecular biology, cell biology, or developmental biology.

In addition to the courses listed below, appropriate courses for graduate students in the Field are Biochemistry, Physiology and Biophysics, and those courses given by the Field of Neurobiology and Behavior.

Students are expected during their first year to spend time and perform experiments in the laboratories of three faculty members of the Field.

A reading knowledge of a foreign language is desirable.

The Field requires a qualifying examination at the end of the first year of residence. At the discretion of the examining committee, the examination may be written, or oral, or both. The Admission to Doctoral Candidacy Examination required

by the Graduate School of Medical Sciences must be taken before six units of residence credit have been accumulated and before substantial progress has been made in the candidate's thesis research.

Courses

Cell Biology and Microscopic Anatomy

Offered by the Staff of the Field of Cell Biology and Genetics, Medical College Division, in conjunction with the Department of Cell Biology and Anatomy, Medical College. This course follows a cellular and differentiative approach aimed at understanding the structure-function correlates that characterize the different tissues and organs. Selected topics are presented in the lectures and laboratory exercises to indicate a pattern of study and depth of analysis that the student can be expected to apply to the study of cells and tissues. A microscope slide collection, presenting tissues and organs in a variety of physiological and developmental states, as well as correlative electron micrographs are provided for individual study in the laboratory. Students must provide their own compound microscopes through their departments or sponsors. Second and third quarters, annually. Drs. Bader and Rodriguez-Boulan.

Gross Anatomy Regional anatomy is studied principally through dissection of the human body. Supplementing this technique are projections by instructors, tutorial group discussions, and radiographic and endoscopic demonstrations. Enrollment is limited and students should consult the staff early in order to determine the availability of places. First and second quarters, annually. The staff.

Advanced Cell Biology Advanced course covering topics in membrane biology, cytoskeleton and cell motility, muscle cell biology, and aspects of nuclear structure and chromosome organization. The course includes lectures and group discussions of assigned research papers. Prerequisite: completion or concurrent enrollment in Microscopic Anatomy, or previous background in basic cell biology. Offered in alternate years. Third and fourth quarters in 1987-88. Dr. Wall and staff.

Genetics A comprehensive course covering classical mendelism through chromosomal,

molecular, somatic cell and developmental genetics. Genetics of human disease and cancer are studied, as well as some immunogenetics, population and evolutionary genetics. In addition to lectures, the course includes some sessions devoted to problem solving. First and second quarters in 1987-88. Drs. German, Siniscalco, and Sirlin.

Molecular Genetics The class focuses on key topics of molecular biology concerning gene structure and organization in prokaryotes and eucaryotes, chromosome structure, DNA replication, protein synthesis and translational and transcriptional control. The use of genetic, biochemical and molecular biological methods to study the questions experimentally is covered in depth. Some topics of current interest such as immune diversity and oncogenes are also covered. The course includes an equal number of lectures and group discussions of representative research papers from the current literature. Prerequisite: background in biological sciences. Limited to 20 students. Offered in alternate years; First and second quarters in 1986-87. Drs. Traktman, Chao, and Neff.

Developmental Biology Principles of descriptive, experimental, and molecular developmental biology are presented, using several animal systems as examples. Early development of the whole organism, and of cells, tissues, and organs are considered. Prerequisites: microscopic anatomy, biochemistry. Limited to 15 students. Offered in alternate years; Third and fourth quarters in 1986-87. Drs. Bachvarova and Bader.

Practicum in Electron Microscopy A workshop in practical aspects of electron microscopy. Following a weekly one hour lecture, students conduct specific protocols involved in electron microscopy. Topics covered include: tissue fixation, embedding and thin sectioning; transmission and scanning electron microscopy; shadow-casting of proteins and nucleic acids; immunocytochemistry; photography. All participants are required to complete an independent project. Prerequisite: consent of instructors. Requirements for passing grade: completion of an independent project paper. Limited to 6 students. Offered in 1987-88 during third and fourth quarters. Dr. Dennis and staff.

Graduate Student Seminar This course is designed to improve graduate students' skills in public presentation. On a rotating basis, students prepare a brief written

abstract and an oral presentation on a topic of their choice. The presentation is informally critiqued by the faculty. First through fourth quarters, annually. Dr. Chao and staff.

Field of Microbiology, Immunology, and Pathology

Field Director

K. I. Berns, Department of Microbiology,
Room B-202, Medical College, (212) 472-
6540

Faculty Representative

C. G. Becker, Department of Pathology,
Room C-444, Medical College, (212) 472-
5983.

The Field of Microbiology, Immunology and Pathology offers graduate training leading to the Ph.D. degree. Under special circumstances candidacy towards the M.S. degree will be considered. The purpose of the graduate program is to provide students with a basic knowledge of molecular and cellular biology, immunology, and of disease processes, as well as approaches to the study of these areas employing the most modern techniques of molecular biology, immunology, and chemistry. It is hoped that a student completing this program will have the information and technical skills to make significant inquiries into the nature of disease processes and to bridge the gap between classical descriptive microbiology and pathology and such disciplines as biochemistry and molecular biology.

Prospective students should complete at the undergraduate level the minimum of one year or its equivalent in general chemistry, organic chemistry, general physics, mathematics (including calculus), botany or zoology (preferably both) and one semester or the equivalent of analytical or quantitative chemistry. Students who have not completed the above requirements may be admitted to graduate study under the condition that deficiencies be corrected

soon after admission. Applicants are ordinarily required to present Graduate Record Examination scores for the aptitude test and for the advanced test in chemistry or biology. Exceptions to these requirements will be considered on behalf of students with advanced standing.

Courses

Microbiology and an Introduction to Infectious Diseases Consists of laboratory exercises, lectures, and group discussions. The laboratory work includes an introduction to the procedures used in studying microorganisms, a survey of the microbial flora of the upper respiratory and lower intestinal tracts of healthy humans, and an intensive study of the causal agents of specific infections, including bacteria, fungi, spirochetes, rickettsiae, and viruses. The lectures are directed toward the development of basic concepts, particularly the principles involved in microbial growth, the principles underlying active immunization, and the factors that enter into host-parasite relationships. Emphasis is placed on the etiology, pathogenesis, epidemiology, and prevention of infectious disease. Offered every year in the first quarter. Dr. Berns and staff.

Advanced Diagnostic Microbiology The lecture and laboratory sessions acquaint the student with the procedures used in and techniques of management of a clinical microbiology laboratory. Emphasis is upon developing the student's capability in the isolation and rapid identification of organisms from various types of clinical specimens. Liberal use is made of clinical materials available through the diagnostic

laboratories of New York Hospital. Offered every year in the third quarter. Hours by arrangement. Dr. Senterfit.

Pathology and Pathophysiology Placed at the interface between the basic sciences and the beginning of the clinical curriculum, the course is a comprehensive study of the structural and functional alterations caused by disease. It starts with an introduction of the principles of general pathology and the basic mechanisms of disease including cell injury and death, inflammation, thrombosis, carcinogenesis and immunopathology. This is followed by the study of the diseases that affect the various organ systems from the etiologic, pathogenetic, structural and functional standpoints and including elements of clinical and laboratory diagnosis. Clinico-pathologic correlations are emphasized throughout the course which is taught with the collaboration of the Departments of Medicine, Pediatrics, Surgery, Neurology, Obstetrics and Gynecology, Ophthalmology and Otorrhinolaryngology.

A major strength of the course is its emphasis on small group teaching. This takes four different formats: 1) microscopic laboratory where students review histologic slides representative of major disease processes, formulate diagnoses, and correlate microscopic findings with clinical signs and symptoms; 2) gross laboratory where students examine actual pathologic specimens under the supervision of a faculty member; 3) pathophysiology exercises where students analyze case histories including diagnostic and pathogenetic considerations under the guidance of a clinical faculty member; and 4) Reviews where a pathologist and clinician challenge students with questions pertaining to subject matter covered on the preceding teaching module. These various formats emphasize problem solving and conceptual thinking by stimulating the student to formulate differential diagnoses and clinico-pathologic correlations. A microcomputer teaching laboratory serves as an adjunct facility for students to review course material, take quizzes and study case histories in preparation for the weekly clinico-pathologic conferences. The laboratory is equipped with ten work stations each consisting of a Macintosh computer, a color video monitor and a video disk player. First

through third quarters, annually. Dr. Ellis and staff.

Introduction to Immunology This annual course, which is organized by the Sloan-Kettering Division but has an interdisciplinary faculty, is required of all students in the Field of Microbiology, Immunology, and Pathology. See under Unit of Immunology, Sloan-Kettering Division, for course description.

Molecular Immunology The course focuses on the molecular biology of receptors on lymphocytes, macrophages, and granulocytes, with an emphasis on the interaction of soluble mediators or microbes with cells of the immune system. Research techniques and methodologies are discussed. The course consists of lectures, readings and discussion. A basic knowledge of immunology equivalent to the introductory course is a prerequisite. Offered in alternate years. Third and fourth quarters in 1987-88. Drs. Edelson and Mosser.

Microbiology Seminar Reports on surveys of the literature in the field and on current research. Presented by graduate students, faculty, and visiting scientists. Attendance is required of all students majoring or minoring in microbiology throughout their programs of study. First through fourth quarters annually. Drs. Berns and Sussdorf.

Other Academic Offerings

Clinical Microbiology Program—Ithaca and New York Campuses During the senior year of a special undergraduate study program on the Ithaca campus or during the year after receiving a bachelor's degree, the student may concentrate on developing skills in clinical microbiology at the Cornell University Medical College-New York Hospital in New York City. Students participate in courses concerned with microbiology, introduction to infectious diseases, diagnostic microbiology, parasitology, immunology, and virology, in addition to working in the hospital diagnostic laboratory. This clinical microbiology specialization is designed to prepare students for employment in clinical microbiology laboratories. However, it could also be selected by students interested in further education or other careers. Dr. Senterfit.

Field of Neurobiology and Behavior

Field Director

T. H. Joh, Department of Neurology, Kips Bay Building, Medical College, (212) 472-5594

Faculty Representative

G. E. Gibson, Department of Neurology, Burke Rehabilitation Center, White Plains, NY, (914) 948-0050, Ext. 2291

The Field of Neurobiology and Behavior provides training in the study of the nervous system. It includes the disciplines of neuroanatomy, neuroembryology, neurophysiology, neuropharmacology, neurochemistry, neuroendocrinology, molecular biology, and neuropsychology and perception. The program of the Field emphasizes a multi-disciplinary approach to the study of the nervous system, based on the belief that future advances in our understanding of the nervous system will be derived from the thinking and research techniques employed by more than one discipline. Toward this end, the program of the students entering the Field is planned in consultation with several staff members, and the students are expected to spend some period of time working closely with members of the faculty whose interests are related to theirs. In addition, there are regularly scheduled seminars in the Field during which various aspects of work in process are presented and discussed. By these means, the students are afforded the broadest possible view of the Field during their total training experience.

The student majoring in Neurobiology and Behavior will be required to satisfy the requirements of the courses in neuroscience, statistics, and biomathematics, and two in the following areas: microscopic anatomy, physiology, biochemistry, and pharmacology. The student must also have two minors, at least one of which is outside the Field. In addition, participation in the seminar program and advanced course offerings is expected. While there are no language requirements, it is suggested that the student achieve mastery of a modern foreign language or a computer programming language. The student choosing

Neurobiology and Behavior as a minor is required to participate in the neuroscience course and the seminar program as well as obtain any additional experience that the minor sponsor may suggest.

Applicants to the Field are expected to have had adequate undergraduate training in biology, organic chemistry, physics, and mathematics. Graduate Record Examination scores are to be submitted with the application. An interview with the applicant is considered highly desirable.

Courses

Neuroscience This is the basic undergraduate medical school course and is required of all major and minor candidates in the Field. It is a broadly based course and introduces the student to neuroanatomy, neurophysiology, and pertinent neurology. Fourth quarter annually. Drs. Brooks and Grafstein.

Neuroscience Seminar Current topics of neurosciences, not included or minimally covered in the Neuroscience course, are examined in detail. The course is required of all major candidates in the Field. Fourth quarter annually. Drs. Brooks and Grafstein.

Neuropharmacology (see Interdivisional Program in Pharmacology).

Behavioral Neuroscience The aim of this course is to examine the neural substrates of a variety of behavioral and mental processes, including attention, perception, learning and memory, emotion, and language. Anatomical, physiological, pharmacological, biochemical, and molecular mechanisms of normal and pathological behaviors will be covered. The course will be divided into 4 lectures on basic mechanisms and 4 seminars exploring methodological and theoretical issues in contemporary behavioral neuroscience. First quarter, 1986-87. Drs. LeDoux and Mann.

Neurochemistry This course will concentrate on the dynamics of neurotransmitter-amino acid, calcium and energy metabolism of the brain. The emphasis will range from in vivo studies in man and animal that relate directly with behavior to purely chemical

approaches. Second quarter, 1986- 1987. Dr. Gibson.

Molecular Neurobiology The aim of this course is to introduce current topics of rapidly developing molecular biology

research in neurosciences. Topics include basic concepts and techniques, structures of genes encoding neuron specific proteins and enzymes, and gene expression in neuronal cells. Third quarter, 1986-1987. Dr. Joh.

Field of Physiology and Biophysics

Field Director

E. E. Windhager, Department of Physiology and Biophysics, Room C-508, Medical College, (212) 472-5229

Faculty Representative

T. Maack, Department of Physiology and Biophysics, Room D-407, Medical College, (212) 472-5281

Opportunities are offered toward the Ph.D. degree in several areas of physiology and biophysics. Ample space is available, and laboratories are well equipped to provide predoctoral training in a medical environment. Interested individuals are urged to contact the Field Director before preparing a formal application. Letters of inquiry should include a discussion of the educational background and indicate possible areas of emphasis in graduate study. There has been a tendency to encourage applications from individuals who have a probable interest in more than one of the areas of physiology represented within the Field.

Applicants must have completed introductory courses in biology, inorganic and organic chemistry, physics, and mathematics through the level of differential and integral calculus. Additional course work in these disciplines at the undergraduate level is encouraged. Applicants with otherwise exemplary records who lack certain course requirements will be considered for acceptance provided that they remedy their deficiencies while in training.

The course of study emphasizes the importance of teaching and research in the preparation and development of individuals for careers in physiology. This goal is achieved by a combination of didactic

courses, seminars, and closely supervised research leading toward the preparation of a satisfactory thesis.

A special program of study will be developed for each student in consultation with his or her Special Committee. In addition to the general requirements set by the Graduate School for all fields, all candidates for the doctoral degree in physiology will be expected to meet the following requirements:

1. Evidence of a satisfactory background in neurosciences. Ordinarily, the course in neuroscience described under the Field of Neurobiology and Behavior, or an equivalent course, will be taken concurrently with the course in physiology and biophysics.
2. Satisfactory completion of the course in physiology and biophysics, or an equivalent course.
3. For majors and minors in the Field, a minimum of two elective courses in the Field ordinarily will be required, in addition to the course in physiology and biophysics.

Courses

Physiology and Biophysics Lectures and conferences on body fluids, bioelectric phenomena, circulation, respiration, and gastrointestinal function. Third quarter, annually. Dr. Windhager and staff.

Lectures and conferences on kidney function, acid-base regulation, endocrinology, and metabolism; and a weekly laboratory on selected aspects of physiology. Fourth quarter, annually. Dr. Windhager and staff.

Topics in Membrane Physiology This weekly conference is designed for Ph.D. and M.D.-Ph.D. students with a major or minor in Physiology and Biophysics. It is at a somewhat advanced level, especially in its quantitative approach to physiology. The aims of the conference are to train students in physiological concepts, to facilitate the understanding of lecture material in the physiology and biophysics course, and to establish close student-faculty contact. Third quarter, annually. Dr. Andersen.

Selected Topics in Kidney and Electrolyte Physiology and Pathophysiology Lectures, seminars and demonstrations. Topics include: 1) GFR, clearance concept, reabsorption and secretion of electrolytes; 2) concentrating mechanism; 3) electrophysiology of the nephron; 4) pathophysiology of potassium; 5) renal blood flow and its intrarenal distribution; 6) renal physiology in the newborn; 7) control of body fluid volume and tonicity; 8) pathology and pathophysiology of renal failure; urinary sediment; 9) radiology of the kidneys; 10) dialysis; 11) transplantation. Minimum of 8 students. Fourth quarter, annually. Drs. Maack, Windhager and staff.

Ionic Channels The course covers mathematical and experimental approaches to the topic of ion movement through single channels. Minimum of 5 students. Prerequisite: 2

years of calculus. Fourth quarter, annually. Dr. Andersen and invited lecturers.

Physiology of Cardiac Muscle The course is designed to present cellular mechanisms which are involved in the fundamental processes of excitation and contraction of cardiac muscle. Topics include: 1) action potential; 2) ion transport; 3) contractility (positive and negative inotropic effects); 4) excitation-contraction coupling; 5) arrhythmias; 6) cardiac failure. One laboratory day is planned for demonstrations of changes in action potential and twitch tension by inotropic agents. Minimum of 5 students. Prerequisites: third quarter physiology or equivalent. Fourth quarter, annually. Dr. Lee and invited lecturers.

Topics in Gastrointestinal Physiology Lectures and Seminars. Topics include: 1) functional morphology of stomach and intestine; 2) proliferation and differentiation of gastrointestinal cells; 3) motility of swell in esophagus, small intestine and colon; 4) gastric and intestinal secretion; pancreatic secretion; 5) lipid absorption; 6) intestinal absorption of calcium and vitamin D; 7) structure and function of bile acids; 8) gastrointestinal hormones. Minimum: 8 students. Fourth quarter, annually. Dr. Martin Lipkin and invited experts in the field.

Instruction at the Sloan-Kettering Division

Graduate Seminar This weekly graduate seminar is offered each year. During the first trimester, second-year students will present brief reports on their research experiences in the laboratory rotations. First-year students may report on laboratory rotations, review a selected area of research, or critically review a research paper. The discussion is carried out principally by graduate students under the guidance of their major (temporary or permanent) sponsors. From time to time outstanding authorities are invited as guest speakers. In addition, students in their third and later years of graduate study address the seminars on the progress being made in their thesis work.

Laboratory Rotations Throughout the year students should spend time in research laboratories. Arrangements for laboratory rotation should be made with the major sponsor.

Minor Projects Two minor subjects are required of all students and they may include some laboratory training, i. e., a minor project. The major sponsor assumes the responsibility for monitoring the time spent on the project. Minor subjects should be completed before the Admission to Doctoral Candidacy Examination.

Laboratory Safety and Biohazards Course All students are required to take by their second year the course of six basic lectures sponsored by the Sloan-Kettering Institute Institutional Biosafety Committee. The series covers general laboratory safety, the use of radiosotopes, carcinogens, primary and secondary barrier systems, contamination control, and hazards associated with research animals, and is supplemented by lectures on special topics given throughout the year.

Unit of Cell Biology and Genetics

Program Chairman

J. L. Biedler, Sloan-Kettering Institute, Walker Laboratory, Room 2127, (914) 698-1100, Ext. 210

Unit Chairman

D. B. Donner, Sloan-Kettering Division, Howard Laboratory, Room 909, (212) 794-7871

Students will spend their first year in: 1) satisfying course and seminar requirements; 2) participating in laboratory rotations; and 3) initiating one or two minor projects. The Unit Chairman will serve as temporary major advisor during this time. At the end of the first year the student's performance will be reviewed and a Special Committee of three members will be selected. The Special Committee membership must

provide multidisciplinary academic backgrounds.

During the second academic year students should complete two minor projects, satisfy the requirements of the Admission to Doctoral Candidacy Examination and initiate a thesis project.

Prerequisites for a major in Cell Biology and Genetics include courses in chemistry (through organic), biochemistry, physics, mathematics (through calculus) and general biological sciences (botany, zoology, microbiology, cell biology); physical chemistry is recommended.

Submission of Graduate Record Examination results, in both aptitude and the advanced test in biology or chemistry is required.

Programs will be determined individually on the basis of interest and prior experience. Students are expected to have knowl-

edge of materials offered in the courses of the Unit and in microscopic anatomy. Exemption from the courses can be granted following the successful completion of a written examination. Students majoring in cell biology may be advised to register for courses in molecular biology, genetics, biochemistry, and biostatistics.

Courses

Topics in Cell Biology and Genetics

This course includes a detailed description of the structure, function and mechanism of action of hormones and growth factors.

Topics include cell surface and intracellular receptors, signal transduction, second messenger generation, regulation of the growth, differentiation and transformation of hemopoietic, gene expression and biochemical pathways. Discussion of the principles of genetics stress the relationship of classical genetics and molecular biology with special reference to the regulation of gene expression during embryonic development. Sessions emphasize discussion of the primary literature and recent advances. First through fourth quarters, annually. Drs. Donner, Eisinger, Moore, and staff.

Other Academic Offerings

Endocrine Research in Progress Seminars

Reports of on-going research by faculty of the Graduate School of Medical Sciences, Cornell University Medical College and Rockefeller University are given weekly. First through fourth quarters.

Regulation of Gene Expression A journal club in which recent literature related to the hormonal regulation of gene expression provides the basis of discussion. Second quarter. Dr. Kourides and staff.

Research Elective in Hormonal Regulation of Gene Expression A laboratory elective in which students will apply methods of molecular endocrinology to the study of gene expression. Requires a commitment of at least two concurrent quarters. Enrollment limited. Dr. Kourides and staff.

Cancer Genetics and Cytogenetics This elective explores the molecular basis of gene and chromosome changes associated with development of human tumors, in particular, leukemia, lymphoma and retinoblastoma. First quarter. Dr. Chaganti and staff.

Unit of Developmental Therapy and Clinical Investigation

Acting Program Co-Chairman

J. J. Fox, Sloan-Kettering Institute, Walker Laboratory, Room 3037, (914) 698-1100, Ext. 225

Unit Chairman

F. M. Sirotnak, Sloan-Kettering Division, Kettering Laboratory, Room 316, (212) 794-7952

In this multidisciplinary program, opportunities for advanced study are focused on laboratory, clinical and/or statistical research as they relate to cancer prevention, diagnosis and treatment. Undergrad-

uate prerequisites vary with the subspecialty area of training in which the student wishes to concentrate; the areas of study offered and their recommended undergraduate backgrounds are reviewed briefly below. Graduate Record Examination results in both the aptitude test and the advanced test in an appropriate area of concentration are required to be submitted by all applicants to the Unit.

1. Instruction toward the Ph.D. degree with emphasis in Biochemical and Molecular Pharmacology, Medicinal Chemistry and Biochemistry, and Cancer Therapeutics.

See Interdivisional Program in Pharmacology for program description (p. 55).

2. Instruction toward the M.S. degree with emphasis in Radiation Biology, Radiation Physics, and Radiopharmaceutics.

Applicants should have a major in biophysics or a major in biology, chemistry, or mathematics, with training in general physics, electricity and magnetism, mechanics, mathematics (through calculus) and thermodynamics.

Students will be required to take advanced instruction in cell and molecular biology, and in physics, biochemistry and mathematics, depending upon the level of prior training.

Candidates are expected to take advanced instruction in physics, biophysics, biology, radiobiology, biochemistry, and biomathematics with a minor in one of these subjects other than physics, and prepare a thesis in the field of radiation physics. Candidates must demonstrate a thorough knowledge of this area in a final written and oral examination.

3. Instruction in Biostatistics.

The program is designed to provide training in statistical theory, methodology, and computing, combined with broad experience in data analysis and collaborative research with medical investigators. Courses to be completed by each student will depend upon the level of prior training and individual interests. In addition to basic probability theory and statistical inference, there is special emphasis on the design and analysis of clinical trials and the development of skills in exploratory data analysis.

Courses

Radiation Physics, Lectures and Problems A series of lectures and assigned problems in applied mathematics, fundamentals of radiation physics, x-ray and radium treatment planning, diagnostic x-ray principles, radiation protection, and uses of radioactive isotopes. First through third quarters, annually. Dr. Laughlin.

Biostatistics I: Introduction to Statistical Reasoning It is the aim of this course to help participants gain some insight into the theory underlying a probabilistic approach to the treatment of observational or experimental data, and to acquaint them with the most basic techniques of statistical analysis. First quarter, annually. Dr. Groshen.

Biostatistics II: Experimental Design and Curve Fitting Application of concepts introduced in Biostatistics I to the analysis of scientific data. Topics include statistical design of experiments, analysis of variance, correlation, and linear regression. Second quarter, annually. Drs. Groshen and Thaler.

Survival Analysis and Clinical Trials Parametric and nonparametric models of survival times, exponential and Weibull distributions; life-table and Kaplan-Meier estimates; design of randomized clinical trials, concomitant variables, stratification, sample size determination; 2- and k-sample techniques for censored data; generalized Wilcoxon and log-rank tests, Cox regression. Third quarter, annually. Dr. Groshen.

Other Academic Offerings

Advanced Biophysics Laboratory rotations in various areas of radiation physics. Hours by arrangement. Dr. Laughlin.

Radiobiology Tutorial in fundamental radiobiology dealing with the effects of radiation on cells, viruses, and macromolecules, as well as on whole animals. Also covered are areas in radiation physics and radiation chemistry pertinent to radiobiology. Dr. Zeitz and staff.

Radiopharmaceutical Chemistry A tutorial in radiopharmaceutical chemistry is offered to students majoring or minoring in this subject. Hours by arrangement. Dr. Gelbard and staff.

Biophysics Colloquia Reports on research in progress by faculty and outside lecturers. Required for majors in biophysics. Hours by arrangement. Staff.

Unit of Immunology

Program Chairman

Osias Stutman, Sloan-Kettering Institute,
Kettering Laboratory, Room 1118, (212)
794-7475

Unit Chairman

Robert W. Knowles, Sloan-Kettering Institute,
Schwartz Laboratory, Room 1001,
(212) 794-7089

Programs are determined individually on the basis of interest, training, prior experience, and consultation with the student's Special Committee. The Unit has no fixed course work requirements other than those set by the student's permanent Special Committee. However, all students majoring in the program are expected to take full advantage of the Unit's core program of formal courses as well as to participate in additional course offerings of the Sloan-Kettering Division, Medical College Division, and other institutions which best complement their previous background and fulfill their scholastic objectives. Students will spend their first year in: 1) satisfying course and seminar requirements; 2) participating in laboratory rotations; and 3) initiating one or two minor projects. The Unit Chairman will serve as temporary major advisor during this time. At the end of the first year, the student's performance will be reviewed and a Special Committee of three members will be selected. The Special Committee includes a major sponsor and two minor sponsors with multidisciplinary academic backgrounds. During the second academic year, students should complete the two minor projects required by the Special Committee, take the Admission to Doctoral Candidacy Examination, and initiate a thesis project. It is the clear intention of the Unit that extensive formal course work should not interfere with participation in the various other activities, such as laboratory rotations, tutorials and minicourses as well as seminars and lectures offered at the Sloan-Kettering Institute and neighboring institutions.

Undergraduate prerequisites include a general college-level background in biology and other sciences, including a strong back-

ground in genetics, biochemistry and microbiology.

Submission of Graduate Record Examination results, in both the aptitude and the advanced test in biology or chemistry, is required.

Courses

Introduction to Immunology This course provides a broad introduction to the field of Immunology and the specific research interests of the faculty. It is designed for first year graduate students and is also open to medical students and senior technologists with no formal training in Immunology. It includes an overview of the immune system, but also covers selected topics in detail.

These topics include techniques in immunology, B lymphocytes, immunoglobulins and monoclonal antibodies, T lymphocytes and T cell clones, immunogenetics of lymphocyte differentiation antigens, cell mediated immunity, T cell antigen receptors, natural cytotoxicity, macrophage and other accessory cells, lymphokines, the serum complement system, the major histocompatibility complex genes and transplantation, HLA and disease associations, and tumor immunology. First and second quarters, annually. Dr. Knowles and the Immunology Unit faculty.

Other Academic Offerings

Colloquia in Immunology Informal sessions between students and senior faculty members to acquaint students with the major research programs headed by each of the faculty members of the Immunology Unit. Students from other units are also welcome to these sessions, which are announced monthly. The colloquia are open to all graduate students at all levels of training.

Laboratory Rotations, Tutorials and Minicourses In order to become familiar with the various research programs which are available to students doing major or minor work in immunology, the Unit advises entering students to participate in as many one-week laboratory rotations,

tutorials and minicourses as can be accommodated into the first-year schedule. The lists and descriptions for laboratory rota-

tions, tutorial programs and minicourses are available from the office of the Unit Chairman.



Instruction in the Interdivisional Programs

Molecular Biology

Interdivisional Program Chairmen

E. Fleissner, Chairman, Program in Molecular Biology, Sloan-Kettering Institute. Kettering Laboratory, Room 923, (212) 794-7494

K. I. Berns, Chairman, Department of Microbiology, Cornell University Medical College; Director, Field of Microbiology, Immunology, and Pathology, Graduate School of Medical Sciences. Medical College, Room B-309, (212) 472-6540

Interdivisional Faculty Representative

K. J. Marians, Sloan-Kettering Institute, Kettering Laboratory, Room 820A, (212) 794-5890.

Admission

A good background in genetics, chemistry or biochemistry is required of students. Graduate Record Examination scores in both the aptitude test and the advanced test in biology or chemistry are also required.

Course Requirements

In the first two years students are expected to complete a core curriculum of Graduate Biochemistry, Molecular Biology, Cell Biology, Nucleic Acids Enzymology, Molecular Virology, Molecular Genetics and Graduate Seminar. Students are also required to take a minimum of two additional courses in order to complete the requirements for the Ph.D.

Minor Requirements and Laboratory Rotations

It is expected that most students will elect to rotate through two or three laboratories. In that event, a written report summarizing the research project undertaken during a rotation through a laboratory other than the one finally chosen for thesis research will fulfill the minor requirement. In the event that the student chooses not to undertake

laboratory rotations and to commence thesis research directly, the Curriculum Committee will assign a written project that will fulfill the minor requirement. The minor requirement must be completed before the student can take the Admission to Doctoral Candidacy Examination.

Admission to Doctoral Candidacy

This Examination will be given once a year in June and consist of two parts, a uniform written exam and an oral defense of a written research proposal. The proposal cannot be in the same field as the student's thesis research. It is expected that most students will take this exam at the end of their second year.

Special Committee

A student's Special Committee will be chosen by the student's mentor in consultation with the Curriculum Committee when the student elects a laboratory for thesis research.

Courses

Molecular Biology A year-long course presenting the fundamentals of eukaryote gene structure, expression and regulation. Topics discussed include: DNA sequence organization, chromatin structure, viral and cellular RNA transcription, translation and its regulation, control of gene expression in model systems and molecular aspects of carcinogenesis. First through fourth quarters. Drs. Sen, Furth, and staff.

Nucleic Acids Enzymology A formal course presenting the enzymological mechanisms and control of prokaryotic and eukaryotic transcription and DNA replication. Enzymes which alter DNA structure and shape are reviewed and topics in DNA repair and recombination are also covered. Graduate Biochemistry is a prerequisite. First and second quarters, 1986-87. Drs. Marians, Hurwitz, and Holloman.

Molecular Virology A formal course in which major emphasis is placed on the basic mechanisms in the biology of all animal viruses, including RNA and DNA tumor viruses. The topics considered include virus structure and composition, assay of viruses and viral-specific products, transcription and replication of viral nucleic acids, translation of virus-specific proteins, assembly of viral particles, structural and functional alterations in viral-infected cells including transformation, pathogenesis of viral diseases, and viral genetics. Third and fourth quarters, 1986-87. Drs. Krug and Berns.

Molecular Genetics This course is designed to familiarize graduate students with practical problems in current research and to encourage critical reading of the scientific literature. Students receive reading assignments and are expected to present short summaries of important experiments at each class meeting. Topics covered include protein structure, protein-nucleic acid interactions, models for transcription factors, genetic complementation, mapping and suppressor analysis in bacteria and yeast. First and second quarters, 1986-87. Dr. Traktman, Chao, and Neff.

Molecular Biology of Growth Control and Neoplastic Transformation This course focuses on current efforts to understand the neoplastic cell phenotype from a molecular point of view. The effects of RNA

and DNA tumor viruses on host cells are discussed, in particular the transformation and/or differentiation blocks of defined cell lineages by certain agents. The nature and enzymatic specificities of viral gene products responsible for transformation are compared with related products of normal cellular genes. The potential interaction of such products with regulatory systems controlling cell shape, adhesiveness, motility, and mitosis are described, as well as the possible involvement of the same systems in nonviral neoplasias. A section of the course is devoted to the molecular biology and biochemistry of cell surface growth factor- and polypeptide hormone-receptors and mechanisms of signal transmission across biological membranes. At least part of the course consists of student presentations on relevant subjects. Third and fourth quarters. Drs. Fleissner, Hayward, Rosen, and staff.

Molecular Parasitology This course focuses on the recent advances in the molecular and biochemical analysis of parasite physiology and their interactions with vertebrate hosts. Lectures are offered once a week, followed by a discussion group. Topics include structures and functions of surface molecules, mechanism of antigen variations and immune evasion, interaction of parasites with targeted cells as well as general aspects of gene organization and expression in various parasites. Third and fourth quarters, 1987-88. Dr. Ravetch.

Pharmacology

Interdivisional Program Chairmen

Chairman: W. W. Y. Chan, Acting Chairman, Department of Pharmacology, Cornell University Medical College, Room E-400, (212) 472-6029

Co-Chairman: J. J. Fox, Acting Co-Chairman, Program of Development Therapy and Clinical Investigation, Sloan-Kettering Institute, Walker Laboratory, Room 3037, (914) 698-1100

Interdivisional Faculty Representative

M. Okamoto, Department of Pharmacology, Cornell University Medical College, Room E-411, (212) 472-5975

This program within the Cornell University Graduate School of Medical Sciences is jointly sponsored by faculties of the Field of Pharmacology of the Medical College Division and the Unit of Developmental

Therapy and Clinical Investigation of the Sloan-Kettering Division. This coordinated faculty provides the student with a broad spectrum of challenging research opportunities in modern pharmacology and a unified curriculum. Students admitted to this program will receive tuition scholarships and stipends.

Admission

A baccalaureate degree with a strong background in the natural sciences and/or health sciences is required for admission. Graduate Record Examination scores in both the aptitude test (verbal, quantitative, and analytical) and the advanced test in Biology or Chemistry are also required for Ph.D. applicants. For applications to the M.D.-Ph.D. program, the results of the Medical College Admission Test are accepted in lieu of the Graduate Record Examination.

Course Requirements

In the first two years students are expected to complete a core curriculum that may include: Graduate Biochemistry, Cell Biology, Physiology, Neuroscience, Graduate Pharmacology, Molecular Pharmacology, Molecular Biology, Immunology, and Graduate Seminar.

Minor Requirements and Laboratory Rotations

Students are required to rotate through two or three laboratories. Until the student selects a major sponsor, the Curriculum Committee will supervise the student's graduate program. The minor requirements must be completed before the student can take the Admission to Doctoral Candidacy Examination.

Admission to Doctoral Candidacy

The Admission to Candidacy Examination consists of two parts: a uniform written exam and an oral defense of a written research proposal. It is expected that most students will take this exam by the end of their second year.

Special Committee

A student's Special Committee will be chosen by the student and major sponsor in consultation with the Curriculum Committee after the student obtains a major sponsor for thesis research.

Courses

General Pharmacology The basic pharmacology course consists of lectures, demonstrations, and small group conferences. The purpose of these exercises is to teach the principles of pharmacology to second-year medical students and to graduate students. Detailed consideration is given to the parameters of drug action to provide the student with the fundamental concepts essential for the evaluation of any drug. Consequently, the scientific basis of pharmacology is emphasized. Prototype drugs, essentially considered systemically, serve to illustrate several mechanisms and parameters of drug action. Therapeutic applications are considered only insofar as they illustrate principles of pharmacology or drug hazards. First quarter, annually. Dr. Chan and staff.

Molecular Pharmacology Fundamental principles and mechanisms governing the effects of chemicals on living systems are examined from the viewpoint of drug-cell interactions. Several theoretical concepts are introduced including drug selectivity, dose-response relationships, and fundamental mechanisms of drug actions. Also discussed are factors that govern the fate and time course of drugs in organisms including: drug absorption, distribution, biotransformation, pharmacokinetics. Examples of receptor isolation, drug-receptor interactions, and effector coupling are also examined. Offered every third year. Offered in 1986-87.

Neuropharmacology This course presents the neuropharmacology of selected drugs and chemical substances that affect the central nervous system. Emphasis is placed on molecular mechanisms of drug actions with regard to the biochemistry and physiology of nervous tissue. These considerations include mechanisms of neurotransmitter actions, including drug actions that

modify neurotransmitter actions. Several pharmacologic concepts important to understanding drug action on the nervous system are considered throughout. These include selectivity, specificity dose-response and receptor theory. Offered in 1986-87. Dr. Okamoto and staff.

Other Academic Offerings

Research in Pharmacology Research opportunities may be arranged throughout the year for graduate students who are not majoring in pharmacology but who want some investigative experience in the discipline. Special opportunities are offered for work on the nervous and cardiovascular systems and in biochemical and clinical aspects of pharmacology. (See Research Activities, p. 55.)

Seminars The Field of Pharmacology offers seminars in areas of interest to the faculty

and graduate students of the Field. Seminars in clinical pharmacology and teaching rounds are held regularly throughout the year. The content, format and schedule of these seminars are determined each year on the basis of the number and backgrounds of the interested students.

Journal Clubs These are offered in areas of pharmacology of special interest. Topics include the role of oxytocin and prostaglandin in labor and dysmenorrhea; regulation of opioid peptide biosynthesis; cardiovascular pharmacology of anaphylactic responses; neuropharmacology of drugs of abuse; clinical and geriatric pharmacology; clinical drug studies in the pediatric population; and prostaglandin and leukotriene pharmacology, their action on cardiovascular and renal systems. Each topic is one quarter in length; see the Faculty Representative for further information.

Register

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Thomas H. Meikle, Jr., Provost for Medical Affairs and Dean of the Medical College

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James A. Sanderson, Chief Investment Officer

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Graduate School of Medical Sciences

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Alison P. Casarett, Dean of the Graduate School

Bernard L. Horecker, Dean of the Graduate School of Medical Sciences, Associate Dean of the Graduate School

Dieter H. Sussdorf, Associate Dean of the Graduate School of Medical Sciences, Assistant Dean of the Graduate School

Richard A. Rifkind, Director, Sloan-Kettering Division

Dorris J. Hutchison, Associate Director, Sloan-Kettering Division; Associate Dean of the Graduate School of Medical Sciences, Assistant Dean of the Graduate School

Standing Committees

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- Minick, C. Richard, Professor of Pathology. B.S. 1957, University of Wyoming; M.D. 1960, Cornell University
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- Murray, Henry W., Associate Professor of Microbiology. B.A. 1968, Cornell University; M.D. 1972, Cornell University Medical College
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- Pickel, Virginia M., Professor of Neurology. B.S. 1965, M.S. 1967, University of Tennessee; Ph.D. 1970, Vanderbilt University
- Pickering, Thomas G., Associate Professor of Medicine. B.A. 1962, M.A. 1968, Cambridge University (England); Ph.D. 1970, Oxford University (England)
- Plum, Fred, Anne Parrish Titzell Professor of Neurology. B.A. 1944, Dartmouth College; M.D. 1947, Cornell University
- Pollack, Marilyn S., Adjunct Assistant Professor of Immunology. A.B. 1961, M.A. 1963, University of California at Berkeley; Ph.D. 1968, Rutgers University
- Posner, Aaron S., Professor of Biochemistry. B.S. 1941, Rutgers University; M.S. 1949, Polytechnic Institute of Brooklyn; Ph.D. 1954, University of Liege (Belgium)
- Prince, Alfred M., Clinical Associate Professor of Pathology. A.B. 1949, Yale University; M.A. 1951, Columbia University; M.D. 1955, Western Reserve University
- Quimby, Fred, Associate Professor of Pathology. V.D.M. 1970, University of Pennsylvania School of Veterinary Medicine; Ph.D. 1974, University of Pennsylvania Graduate School of Arts and Sciences
- Rabellino, Enrique M., Assistant Professor of Medicine. B.S. 1959, Institute J. M. Paz (Argentina); M.D. 1965, University of Cordoba (Argentina)
- Rachele, Julian R., Emeritus Professor of Biochemistry. B.A. 1934, M.S. 1935, Ph.D. 1939, New York University
- Ravetch, Jeffrey A., Associate Professor of Molecular Biology. B.S. 1973, Yale University; Ph.D. 1978, Rockefeller University; M.D. 1979, Cornell University
- Ray, James H., Adjunct Assistant Professor of Cell Biology and Anatomy, B.A. 1967, Murray State University; M.S. 1969, University of Kentucky, Ph.D. 1976, University of Houston
- Rayson, Barbara, Assistant Professor of Physiology and Biophysics; Assistant Professor of Medicine in Physiology. B.Sc. 1972, Ph.D. 1976, University of Melbourne (Australia)
- Reidenberg, Marcus M., Professor of Pharmacology. B.S. 1954, Cornell University; M.D. 1958, Temple University
- Reis, Donald J., George C. Cotzias Distinguished Professor of Neurology. A.B. 1953, M.D. 1956, Cornell University
- Rifkind, Arleen B., Professor of Pharmacology; Associate Professor of Medicine. B.A. 1960, Bryn Mawr College; M.D. 1964, New York University
- Rifkind, Richard A., Professor of Cell Biology and Genetics. B.S. 1951, Yale University; M.D. 1955, Columbia University
- Riker, Walter F. Jr., Professor of Pharmacology. B.S. 1939, Columbia University; M.D. 1943, Cornell University

- Risley, Michael, Associate Professor of Cell Biology and Anatomy. B.S. 1970, Manhattan College; Ph.D. 1976, City University of New York
- Rodman, Toby C., Professor of Cell Biology and Anatomy. B.S. 1937, Philadelphia College of Pharmacy and Science; M.S. 1961, Ph.D. 1963, New York University
- Rodriguez-Boulán, Enrique, Associate Professor of Cell Biology and Anatomy. B.A. 1963, National College of Buenos Aires; M.D. 1970, University of Buenos Aires (Argentina)
- Rosen, Ora M., Professor of Molecular Biology. B.A. 1956, Barnard College; M.D. 1960, Columbia University
- Rothermel, Constance Davis, Assistant Professor of Microbiology, B.S. 1964, West Virginia University; M.S. 1967, University of North Carolina; Ph.D. 1980, Cornell University Graduate School of Medical Sciences
- Rottenberg, David A., Associate Professor of Neurology. B. A. 1963, University of Michigan; M.Sc. 1967, University of Cambridge (England); M.D. 1969, Harvard University
- Rubin, Albert L., Professor of Biochemistry in Surgery, M.D. 1950, Cornell University
- Ruggiero, David A., Assistant Professor of Neurobiology in Neurology, B.A. 1972, Queens College of the City University of New York; M.A. 1976, M. Phil. 1977, Ph.D. 1977, Columbia University
- Safai, Bijan, Assistant Professor of Immunology. M.D. 1965, University of Teheran Medical School (Iran)
- Santos-Buch, Charles A., Professor of Pathology. A.B. 1953, Harvard University; M.D. 1957, Cornell University
- Saxena, Brij B., Professor of Endocrinology in Obstetrics and Gynecology. Ph.D. 1954, University of Lucknow (India); D. Sc. 1957, University of Münster (Germany); Ph.D. 1961, University of Wisconsin
- Schleifer, Leonard S., Assistant Professor of Neurology, A.B. 1973, Cornell University; M.D. 1977, University of Virginia School of Medicine; Ph.D. 1980, University of Virginia
- Schubert, Edward T., Assistant Professor of Biochemistry in Pediatrics. B.S. 1949, M.S. 1952, Ph.D. 1959, Fordham University
- Schwartz, Morton K., Professor of Developmental Therapy and Clinical Investigation. B.A. 1948, Lehigh University; Ph.D. 1952, Boston University
- Sechzer, Jeri A., Associate Professor of Psychology in Psychiatry. B.S. 1956, New York University; M.A. 1961, Ph.D. 1962, University of Pennsylvania
- Sen, Ganes C., Associate Professor of Molecular Biology. B.S. 1965, M.S. 1967, Calcutta University (India); Ph.D. 1974, McMaster University (Canada)
- Senterfit, Laurence B., Professor of Microbiology. B.S. 1949, M.S. 1950, University of Florida; Sc.D. 1955, Johns Hopkins University
- Shapiro, Joan Rankin, Assistant Professor of Cell Biology in Neurology. B.S. 1960, Westminster College; M.S. 1968, New York University; M.A. 1970, Hofstra University; Ph.D. 1979, Cornell University
- Sheffery, Michael, Assistant Professor of Molecular Biology. A.B. 1975, M.S. 1977, Ph.D. 1981, Princeton University
- Shen, Fung-Win, Associate Professor of Immunology, B.S. 1968, Fu-Jen Catholic University (Taiwan); M.S. 1971, Ph.D. 1973, University of New Mexico
- Sherline, Peter, Associate Professor of Medicine; A.B. and M.D. 1968, Boston University Medical School
- Silagi, Selma, Professor of Genetics in Obstetrics and Gynecology. A.B. 1936, Hunter College; Ph.D. 1961, Columbia University
- Siniscalco, Marcello, Professor of Cell Biology and Genetics. M.D. 1948, University of Naples (Italy)

- Sirlin, Julio L., Professor of Cell Biology and Anatomy. D.Sc. 1953, University of Buenos Aires (Argentina)
- Sirotnak, Francis M., Professor of Developmental Therapy and Clinical Investigation. B.S. 1950, University of Scranton; Ph.D. 1954, University of Maryland
- Siskind, Gregory W., Professor of Medicine. B.A. 1955, Cornell University; M.D. 1959, New York University
- Smith, Gerard P., Professor of Psychiatry (Behavioral Science). B.S. 1956, St. Joseph's College; M.D. 1960, University of Pennsylvania
- Soffer, Richard L., Professor of Biochemistry and Medicine. B.A. 1954, Amherst College; M.D. 1958, Harvard University
- Sonenberg, Martin, Professor of Cell Biology and Genetics. B.S. 1941, University of Pennsylvania; M.D. 1944, Ph.D. 1952, New York University
- Staiano-Coico, Lisa, Assistant Professor of Cell Biology and Anatomy, B.S. 1976, Brooklyn College, Ph.D. 1981, Cornell University Graduate School of Medical Sciences
- Stavnezer, Edward, Adjunct Assistant Professor of Molecular Biology. B.A. 1965, M.S. 1967, University of Connecticut; Ph.D. 1971, Johns Hopkins University
- Stenzel, Kurt H., Professor of Medicine; Professor of Biochemistry in Surgery. B.S. 1954, New York University; M.D. 1958, Cornell University
- Stephenson, John L., Professor of Biomathematics in Physiology. B.A. 1943, Harvard University; M.D. 1949, University of Illinois
- Sternberg, Stephen S., Professor of Developmental Therapy and Clinical Investigation. B.A. 1941, Colby College; M.D. 1944, New York University
- Stokes, Peter E., Associate Professor of Medicine and Psychiatry. B.S. 1958, Trinity College; M.D. 1952, Cornell University
- Stutman, Osias, Professor of Immunology. B.A. 1950, Colegio Nacional Sarmiento (Argentina); M.D. 1957, Buenos Aires University Medical School (Argentina)
- Sugg, John V., Emeritus Professor of Microbiology. A.B. 1926, M.S. 1928, Ph.D. 1931, Vanderbilt University
- Sussdorf, Dieter H., Associate Professor of Microbiology. B.A. 1952, University of Missouri; Ph.D. 1956, University of Chicago
- Szabo, Paul, Assistant Professor of Molecular Biology in Medicine; B.S. 1971, Ph.D. 1974, University of Illinois
- Szeto, Hazel H., Associate Professor of Pharmacology. B.S. 1972, Indiana University; Ph.D., M.D. 1977, Cornell University
- Tate, Suresh S., Associate Professor of Biochemistry. B.Sc. 1958, M.Sc. 1960, University of Baroda (India); Ph.D. 1963, University of London (England)
- Teintze, Martin, Assistant Professor of Cell Biology and Anatomy, B.S. 1976, California Institute of Technology; Ph.D. 1981, University of California
- Teitelman, Gladys N., Assistant Professor of Neurobiology in Neurology. Licenciada in Biology 1962, University of Buenos Aires (Argentina); Ph.D. 1971, University of Pennsylvania
- Thaler, Howard T., Assistant Professor of Developmental Therapy and Clinical Investigation. B.A. 1967, University of California at Los Angeles; Ph.D. 1974, State University of New York at Buffalo
- Townes-Anderson, Ellen, Assistant Professor of Physiology and Biophysics. B.A. 1968, Connecticut College; M.A. 1971, University of California at Berkeley; Ph.D. 1980, Boston University School of Medicine
- Traktman, Paula, Assistant Professor of Cell Biology and Anatomy. A.B. 1974, Radcliffe College, Harvard University; Ph.D. 1981, Massachusetts Institute of Technology
- Udenfriend, Sidney, Adjunct Professor of Biochemistry. B.S. 1939, City College of New York; M.S. 1942, Ph.D. 1948, New York University
- Urban, Bernd W., Assistant Professor of Physiology and Biophysics. Diplom der Physik (Master) 1974, University of Karlsruhe (West Germany); Ph.D. 1978, University of Cambridge (England)

- Wall, Doris A., Assistant Professor of Cell Biology and Anatomy. B.A. 1970, University of New Hampshire; Ph.D. 1975, Cornell University
- Watanabe, Kyoichi A., Professor of Developmental Therapy and Clinical Investigation. Ph.D. 1963, Hokkaido University (Japan)
- Weinstein, Alan M., Assistant Professor of Physiology and Biophysics. A.B. 1971, Princeton University; M.D. 1975, Harvard University
- Weksler, Babette B., Professor of Medicine. B.A. 1958, Swarthmore College; M.D. 1963, Columbia University
- Weksler, Marc E., Irving Sherwood Wright Professor of Geriatrics; Professor of Medicine. B.A. 1958, Swarthmore College; M.D. 1962, Columbia University
- Wellner, Daniel, Associate Professor of Biochemistry. A.B. 1956, Harvard University; Ph.D. 1961, Tufts University
- Windhager, Erich E., Maxwell M. Upson Professor of Physiology and Biophysics. M.D. 1954, University of Vienna (Austria)
- Wong, George Y., Assistant Professor of Developmental Therapy and Clinical Investigation. B.A. 1973, Rice University; M.A. 1975, Ph.D. 1978, Harvard University
- Woods, Kenneth R., Associate Professor of Biochemistry. B.A. 1948, Arizona State University; Ph.D. 1955, University of Minnesota
- Yang, Soo Young, Assistant Professor of Immunology. M.S. 1972, Minnesota State University; Ph.D. 1981, New York University
- Young, Robert C., Assistant Professor of Psychiatry in Neurobiology. B.A. 1969, Williams College; M.D. 1974, Cornell University
- Zakim, David, Vincent Astor Distinguished Professor of Medicine. B.A. 1956, Cornell University; M.D. 1961, State University of New York Downstate Medical Center
- Zeitz, Louis, Associate Professor of Developmental Therapy and Clinical Investigation. A.B. 1948, University of California; Ph.D. 1962, Stanford University

Degree Recipients 1985-86

Doctors of Philosophy

- Belkowski, Linda S., B.A. 1979, Rutgers University. Molecular Biology, Professor Ganes Sen. Thesis: "Interferon-Mediated Inhibition of Vesicular Stomatitis Virus Replication in Cells with Differential Interferon Sensitivities"
- Bergold, Peter J., B.S. 1977, Trinity College. Molecular Biology, Professor Peter Besmer. Thesis: "Feline *abl*-Containing Retrovirus and their Role in Oncogenesis"
- Brodeur, David, B.S. 1979, College of William and Mary. Molecular Biology, Professor Edward Stavnezer. Thesis: "Identification and Analysis of Polypeptides Containing A Domain Encoded by the Oncogene *v-ski* of the SK Viruses"
- Chan, Marion Man-Ying, B.S. 1975, M.S. 1978, University of Maryland. Immunology, Professor Osias Stutman. Thesis: "Functional and Biochemical Characterization of Two Murine Lymphocyte Antigens, Ly-10 and Ly-22, Defined by Monoclonal Antibodies"
- Chaum, Edward, B.A. 1979, Johns Hopkins University. Cell Biology and Genetics, Professor Raju Chaganti. Thesis: "Cytogenetic and Molecular Studies of the Role of Oncogenes in Transformation in Retinoblastoma"
- Chen, Yao-Tseng, B.Med. 1981, College of Medicine, National Taiwan University. Immunobiology, Professor Lloyd J. Old. Thesis: "Thymus-Leukemia (TL) Antigens of the Mouse: Analysis of TL Genes, TLmRNA, and TLcDNA"
- Colmenares, Clemencia, B.S. 1976, Yale University. Immunology, Professor Carlos Lopez. Thesis: "Natural Cell-Mediated Cyto-toxicity Against Herpes Simplex Virus Type 1 Infected Cells and Its Role in Murine Natural Resistance to HSV-1"
- Davatelis, George N., B.A. 1977, Montclair State College, M.S. 1979, University of Hawaii. Cell Biology and Genetics, Professor Marcello Siniscalco. Thesis: "The Isolation and Characterization of Cloned Molecular Probes for Mapping the Human X-Chromosome"
- DiPaola, Eugene A., B.S. 1974, Manhattan College. Cell Biology and Genetics, Professor Richard Sterner. Thesis: "Characterization and Biological Significance of Deacetylases"
- Harris, Paul E., A.B. 1978, University of California. Cell Biology and Genetics, Professor Malcolm A. S. Moore. Thesis: "Biological and Biochemical Characterization of Cytokine-Induced Differentiation of the Human Myelogenous Leukemia Cell Lines HL-60 and U937"
- Hodes, Marquis Z., A.B. 1973, Indiana University at Bloomington; M.S. 1976, Indiana University at Indianapolis. Immunology, Professor Richard J. O'Reilly. Thesis: "Bone Marrow Transplantation Using Lectin Fractionated Marrow in Mouse and Man"
- Jeong, Gajin, B.S. 1976, M.S. 1978, Seoul National University. Cell Biology and Genetics, Professor Peter Ralph. Thesis: "Human B Lymphocyte-inducing Factor: Production, Characterization, and Induction of Immunoglobulin-secreting Cells in Stimulated B Lymphocytes"
- Klein, Deborah, B.A. 1973, New York University; M.S. 1978, Fordham University. Cell Biology and Genetics, Professor Janet Stavnezer. Thesis: "Somatic Mutation Occurs During a Proscribed Period of B Cell Development Before Isotype Switch in the 1.29 Lymphoma"
- Lee, William T. L., B.A. 1978, Johns Hopkins University. Cell Biology and Genetics, Professor Nurul H. Sarkar. Thesis: "Characterization of a Variant Murine Mammary Tumor Virus Provirus in a DBA/2 Mouse T-Cell Leukemia"

Montgomery, Kate L., B.A. 1978, Vassar College. Molecular Biology, Professor Peter W. Melera. Thesis: "Studies on Gene Amplification in Human Neuroblastoma"

Mynarcik, Dennis C., B.S. 1978, University of Texas at San Antonio. Biochemistry, Professor Gordon F. Fairclough, Jr. Thesis: "Pulmonary Surfactant Acidic Phospholipid Biosynthesis: A Role for the Lamellar Body"

Rico-Hesse, Rebeca, B.S. 1978, University of Nebraska, M.P.H. 1980, University of Minnesota. Microbiology, Professor Robert W. Dickerman. Thesis: "Epidemiology and Characterization of the the I-D Subtype of VEE Virus in Columbia"

Riley, Richard J., B.S. 1972, Manhattan College; M.S. 1976, New York University. Developmental Therapy and Clinical Investigation, Professor John S. Laughlin. Thesis: "Aspects of Electron Dosimetry"

Rubino, Stephen D., B.S. 1980, Muhlenberg College. Microbiology, Professor Michael E. Wiebe. Thesis: "The Nature of the Interactions Between Sendai Virus and Human Leukocytes Which Leads to Interferon Induction"

Wallace, David, B.S. 1966, City University of New York. Microbiology, Professor Gregory W. Siskind. Thesis: "Function of Mouse Immunoglobulin D"

Masters of Science

Gudewill, Ellen V., B.S. 1979, State University of New York at Stony Brook. Pathology, Professor Carl Becker. Thesis: "Plasmin-Derived C3a Anaphylatoxin"

Mirenda, Carol A., B.A. 1979, Rutgers University. Molecular Biology and Virology, Professor Allen Oliff. Thesis: "A Study of the Murine Retroviral Genomic Domains Required for the Induction of Leukemia"

Ruether, James E., B.A. 1981, University of Colorado. Molecular Biology and Virology, Professor Selina Chen-Kiang. Thesis: "Expression of Mouse Immunoglobulin MU Gene in an Adenovirus Vector"

Students 1986-87

Candidates for the Degree of Doctor of Philosophy

Abate, Corinne, B.A. 1983, Fordham University. Major: Neurobiology and Behavior. Brooklyn, New York

Ark, Belinda C., A.B. 1984, Cornell University. Major: Cell Biology and Genetics. San Francisco, California

Arnold, James B., B.A. 1982, Columbia College. Major: Neurobiology and Behavior. New York, New York

³⁾Askari, Frederick K., B.A. 1981, Cornell University, Major: Pharmacology. Toledo, Ohio

Barnhart, Kerry M., B.S. 1983, M.S. 1985, University of Arizona. Major: Molecular Biology. Tucson, Arizona

¹⁾Batter, David K., B.S. 1979, University of Connecticut. Major: Cell Biology and Genetics. New Haven, Connecticut

Bauchwitz, Robert P., B.A. 1982, Harvard University. Major: Molecular Biology. Wilmington, Delaware

Bayer, Virginia E., B.A./B.S. 1981, University of California. Major: Neurobiology and Behavior. Newport Beach, California

Berger, Scott B., B.A. 1983, Emory University. Major: Neurobiology and Behavior. Pittsburgh, Pennsylvania

³⁾Blank, Seymour G., B.E.E. 1965, City University of New York: M.E.E. 1968, New York University. Major: Physiology and Biophysics. Brooklyn, New York

Blumenthal, Jeffrey A., B.A. 1985, Vassar College. Major: Immunology. Glenwood, Illinois

³⁾Brennan, Lynn A., B.A. 1974, Rutgers University. Major: Molecular Biology. New York, New York

Brock, Alice M., A.B. 1978, Smith College; M.S.H.S. 1980, Northeastern University. Major: Cell Biology and Genetics, Scarsdale, New York

¹⁾in absentia

²⁾leave of absence

³⁾candidate for degree only

- Brooks, David G., B.A. 1982, University of Colorado; M.S. 1984, Michigan State University. Major: Cell Biology and Genetics. Rochester, Michigan
- Buck, Charles R., B.S. 1983, College of Idaho. Major: Cell Biology and Genetics. Caldwell, Idaho
- ²⁾Choy, Janet Wing, A.B. 1977, Smith College. Major: Cell Biology and Genetics. Wayne, New Jersey
- Clurman, Bruce E., B.A. 1981, University of Virginia. Major: Molecular Biology. Cherry Hill, New Jersey
- Cuerdon, Elizabeth F., B.S. 1985, Siena College. Major: Microbiology, Immunology, and Pathology. Loudonville, New York
- Dicker, Adam P., B.A. 1984, Columbia University. Major: Cell Biology and Genetics. Great Neck, New York
- DiSanto, James P., B.A. 1983, Johns Hopkins University. Major: Development Therapy and Clinical Investigation. Cherry Hill, New Jersey
- Donnelly, Robert E., B.S. 1985, University of California. Major: Biochemistry. Cupertino, California
- Doucette, Lynn Anne, B.Sc. 1981, McMaster University (Canada). Major: Cell Biology and Genetics. Toronto, Canada
- Drozdoﬀ, Vladimir V., B.A. 1979, Bowdoin College. Major: Developmental Therapy and Clinical Investigation. Cooper, Maine
- Einheber, Steven, B.S. 1981, George Washington University. Major: Cell Biology and Genetics. Washington, D.C.
- Ennulat, Cynthia L., B.A. 1980, State University of New York, Oswego; M.S. 1985, Syracuse University. Major: Cell Biology and Genetics. Brewerton, New York
- Escandon, Enrique M., B.S. 1983, M.S. 1985, Universidad Nacional Autonoma de Mexico. Major: Cell Biology and Genetics. Mexico City, Mexico
- Evans, Elizabeth V., B.A. 1980, Bennington College. Major: Cell Biology and Genetics. La Jolla, California
- Febbraio, Maria, B.S. 1982, Fordham University. Major: Microbiology, Immunology, and Pathology. Staten Island, New York
- Fernandez-Almonacid, Rafael, B.Sc. 1980, M.Sc. 1985, Universidad Austral De Chile. Major: Molecular Biology. Valdivia, Chile
- Firpo, Meri T., B.A. 1984, Carroll College. Major: Cell Biology and Genetics. Helena, Montana
- Fotheringham, Robert Scott, B.Sc. 1985, University of Guelph. Major: Molecular Biology. Ontario, Canada
- Foxman, Brett, B.A. 1982, Boston University; M.D. 1982, Boston University School of Medicine. Major: Neurobiology and Behavior. Penn Valley, Pennsylvania
- Gamble, David A., D.V.M. 1978, Washington State University. Major: Microbiology, Immunology, and Pathology. Ithaca, New York
- ³⁾Green, William Nathan, B.Sc. 1978, University of Toronto. Major: Physiology and Biophysics. Buffalo, New York
- Greenlee, Paul G., B.S. 1977, Oklahoma State University; D.V.M. 1980, Oklahoma State University; M.S. 1982, Oklahoma State University. Major: Microbiology, Immunology, and Pathology. New York, New York
- Groden, Joanna L, B.A. 1978, Middlebury College. Major: Cell Biology and Genetics. Cambridge, Massachusetts
- Gulati, Poonam, B.A. 1982, Cornell University. Major: Microbiology, Immunology, and Pathology. Collins, New York
- Gummere, Gregory R., B.A. 1979, M.S. 1981, University of Cincinnati. Major: Cell Biology and Genetics. Cincinnati, Ohio
- Gundersen, Doris I., B.A. 1977, Clark University. Major: Cell Biology and Genetics. West Babylon, New York
- Hachfeld, Ughetta del Balzo, B.A. 1981, Barnard College. Major: Pharmacology. Rome, Italy
- Hahn, Mounou, B.S. 1985, University of Wisconsin. Major: Molecular Biology. Seoul, Korea

- Hahn, Soonjung Lucia, B.S. 1983, Seoul National University; M.S. 1985, University of Wisconsin. Major: Molecular Biology. Seoul, Korea
- Hariri, Robert, B.A. 1980, Columbian College. Major: Microbiology, Immunology, and Pathology. Forest Hills, New York
- Harris, Andrea, B.A. 1979, Boston University. Major: Microbiology, Immunology, and Pathology. Hampton Bays, New York
- Hearn, Timothy J., B.S. 1983, Penn State University. Major: Neurobiology and Behavior. Camp Hill, Pennsylvania
- Heinrich, N. Julia, B.A. 1977, Brown University. Major: Molecular Biology. New York, New York
- Hodgins, Gregory W. L., B.Sc. 1985, University of Toronto. Major: Immunology. Ontario, Canada
- Hong, Guangyuan, B.S. 1982, M.S. 1985, Peking University. Major: Molecular Biology. Peking, People's Republic of China
- Hume, Clifford R., B.A. 1983, Carleton College. Major: Immunology. Incline Village, Nevada
- Hwang, Onyou, A.B. 1982, Smith College. Major: Neurobiology and Behavior. Seoul, Korea
- Jenkins, Deborah L., B.A. 1983, Williams College. Major: Biochemistry. Amherst, Massachusetts
- Kanter, Madge R., B.A. 1982, University of California at Santa Cruz. Major: Molecular Biology. Palo Alto, California
- Kelly, Catherine D., B.A. 1981, State University of New York at Purchase. Major: Microbiology, Immunology, and Pathology. Rockville Centre, New York
- Kenny, Mark K., B.A. 1983, Wesleyan University. Major: Molecular Biology. Chappaqua, New York
- Kim, Chul Geun, B.S. 1981, Han Yang University; M.S. 1983, Seoul National University. Major: Molecular Biology. Yesan, Korea
- Knudsen, Beatrice S., M.S. 1982, University of Vienna. Major: Cell Biology and Genetics. Vienna, Austria
- Kornack, David R., B.S. 1983, Northern Illinois University. Major: Neurobiology and Behavior. Lombard, Illinois
- Künzi, Myriam S., B.A. 1984, Wellesley College. Major: Cell Biology and Genetics. Upper Malboro, Maryland
- Lader, Eric Scott, B.S. 1981, Brooklyn College. Major: Cell Biology and Genetics. Brooklyn, New York
- Lee, Jin-Moo, B.A. 1985, Yale University. Fort Washington, Maryland
- Lee, Myung Soo, M.D. 1979, M.M.S. 1980 Seoul National University (Korea). Major: Immunology. Dongdaemum-ku, Seoul, Korea
- Leonard, Christopher, J., B.S. 1985, Cornell University. Major: Microbiology, Immunology, and Pathology. Rochester, New York
- Le Strange, Renee C., B.A. 1978, University of North Carolina. Major: Immunology. Long Branch, New Jersey
- ²⁾Levine, Sulamita, M.D. 1975, M.S. 1980, University of Zulia Medical School (Venezuela). Major: Neurobiology and Behavior. Maracaibo, Venezuela
- Li, Luyuan, Graduate Certificate 1982, Sichuan University. Major: Biochemistry. Zunyi City, People's Republic of China
- Lisanti, Michael, P., B.A. 1985, New York University. Major: Cell Biology and Genetics. Rockaway Beach, New York
- Litherland, Sally A., B.S. 1981, University of Florida; M.S. 1983 University of Florida. Major: Microbiology, Immunology and Pathology. Satellite Beach, Florida
- Liu, Su, M.D. 1982, Shanghai First Medical College. Major: Cell Biology and Genetics. Hunan, China
- Lu, Bai, B.S. 1982, East China Normal University; M.Sc. 1985, Shanghai First Medical College. Major: Neurobiology and Behavior. Shanghai, People's Republic of China

- ¹⁾Lufkin, Thomas C., A.B. 1981, University of California, Berkeley. Major: Molecular Biology. Birmingham, Michigan
- Maddock, Anne E., B.A. 1985, Yale University. Major: Neurobiology and Behavior. Fairfield, Connecticut
- Maher, Kevin J., B.S. 1984, Manhattan College. Major: Microbiology, Immunology, and Pathology. Yonkers, New York
- Maki, Robert G., B.A. 1985, Northwestern University. Major: Cell Biology and Genetics. Omaha, Nebraska
- Mandell, James W., A.B. 1984, Cornell University. Major: Neurobiology and Behavior. Charlottesville, Virginia
- Marino, Michael W., B.A. 1983, Skidmore College; M.S. 1985, University of Texas. Major: Cell Biology and Genetics. Racine, Wisconsin
- Martinez, Humberto Jose, M.D. 1975, University of Zulia Medical School (Venezuela). Major: Neurobiology and Behavior. Maracaibo, Venezuela
- ¹⁾Maurer, David H., A.B. 1977, Cornell University. Major: Immunology. Newburgh, New York
- McNerney Mary Ellen, B.S. 1977, M.S. 1983, St. John's University. Major: Pharmacology. Huntington, New York
- Meyers, Lillian R. S., A.B. 1984, Brown University. Major: Biology. Chicago, Illinois
- Michitsch, Richard W., B.A. 1975, M.S. 1978, New York University. Major: Molecular Biology. Brooklyn, New York
- Mok, Minsan, B.A. 1982, Johns Hopkins University. Major: Cell Biology and Genetics. Convent Station, New Jersey
- Moncrieff, Patrice M., B.S. 1984, Boston College. Major: Cell Biology and Genetics. Park Ridge, New Jersey
- Nicholson, Andrew C., B.S. 1973, D.V.M. 1976, Michigan State University. Major: Microbiology, Immunology, and Pathology. Bangor, Maine
- Nocka, Karl H., B.A. 1983, Bowdoin College. Major: Molecular Biology. Ridgewood, New Jersey
- Nussenzweig, Daniel R., M.D. 1980, University of Sao Paulo. Major: Physiology and Biophysics. Sao Paulo, Brazil
- Parada, Camilo A., B.S. 1978, Licence Biology (Master of Science) 1981, Catholic University of Valparaiso (Chile). Major: Molecular Biology. White Plains, New York
- Patil, Nila J., B.A. 1980, University of Buffalo. Major: Cell Biology and Genetics. Buffalo, New York
- Pearse, Roger N., B.A. 1977, Dartmouth College. Major: Microbiology, Immunology, and Pathology. Newport, Rhode Island
- Pincus, David W., B.S. 1985, Yale University. Hampden, Massachusetts
- Qiu, Feihua, M.D. 1979, Beijing Medical College. Major: Molecular Biology. Shanghai, People's Republic of China
- Qiu, Wei-Qiao, M.D. 1982, Peking Medical College. Major: Immunology. Peking, People's Republic of China
- Ramakrishna, Naren R., B.A. 1985, Johns Hopkins University. Charleston, West Virginia
- Robertson, Donna A., B.S. 1979, Syracuse University. Major: Pharmacology. White Plains, New York
- ²⁾Rosenberg, Charles D., A.B. 1978, Washington University; M.S. 1979, State University of New York at Buffalo. Major: Cell Biology and Genetics. Merrick, New York
- Rosenberg, Elizabeth A., B.A. 1981, Wesleyan University. Major: Biochemistry. New York, New York
- Rubino, Heidi M., B.S. 1980, Muhlenberg College. Major: Biochemistry. New York, New York
- Russell, David S., B.A. 1982, Oberlin College. Major: Molecular Biology. Chagrin Falls, Ohio
- Sehgal, Amita, B.Sc. 1981, Delhi University (India); M.Sc. 1983, Jawaharlal Nehru University School of Life Sciences (India); Major: Cell Biology and Genetics. New Delhi, India

- Shaffer, Rose Mary, B.S. 1980, Loyola College. Major: Microbiology, Immunology, and Pathology. Baltimore, Maryland
- Shapiro, Geoffrey I., B.A. 1981, Columbia University. Major: Molecular Biology. Schenectady, New York
- Signorelli, Kathy L., B.A. 1982, Wellesley College. Major: Molecular Biology. Strongsville, Ohio
- Solomon, David H., A.B. 1982, Oberlin College. Major: Molecular Biology. Montreal, Canada
- ²⁾Sordillo, Emilia M., A.B. 1976, Harvard University; M.D. 1980, Cornell University. Major: Immunology. New York, New York
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